ESSENTIALS OF

REFRACTION

AND OF

DISEASES OF THE EYE

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SAUNDERS' QUESTION-COMPENDS. No. 14.

ESSENTIALS OF REFRACTION

AND OF

DISEASES OF THE EYE

WITH A CONSIDERATION OF

Ocular Injuries and the Ocular Symptoms of General Diseases

BY

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FOURTH EDITION, REVISED AND ENLARGED

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PREFACE TO THE FOURTH EDITION.

THE form of the Question Compend, the arrangement of its contents in questions and answers, seems too often to suggest but one use—cramming for examinations. But its continued popularity demonstrates that students and readers appreciate (what was understood from the first by publisher and author) that this form lends itself admirably to more general and important uses. The most striking advance in the form of text-books that has occurred of late years is the general use of headings, which indicate at a glance what the paragraphs contain. The questions printed in heavy-face type serve perfectly the purpose of such headings If well chosen they show the scope of the paragraph, or emphasize the important idea of the text which is given as an answer.

The dogmatic statement, which seems so appropriate in the answering of a question, may be at variance with the spirit of investigation; but it serves well the purpose of teaching. The form of questions and answers compels a certain brevity and directness, which might easily be missed when writing in the more common form.

Again, in referring to a text-book the busy practitioner comes with a question. To find the information he wants in the form of an answer seems natural and satisfactory. Too often the question answered in the book will not be exactly the question he has in mind; and yet from the question headings and the paragraph answers, he will be able to obtain the information desired at least as quickly, as from any other form of statement.

While the alterations made in the present edition are numerous, they are generally brief. The greatest changes have been with reference to the mechanism of accommodation, the description of various forms of lenses, the treatment of disorders of ocular movements, and the account of some of the newer therapeutic agents, like argyrol, adrenalin, and dionin. Drugs, like stovaine, that do not seem to have positive advantages over the older remedies that they might replace, and therapeutic agents, like the high-frequency current, or the use of heated air, the proper applications for which are not definitely established, have been omitted.

As befits the importance of the suggestion, the student is once more urged to supplement reading by seeing and doing; or better, to make reading an aid to the actual study of cases.

EDWARD JACKSON.

DENVER, April, 1906.

PREFACE.

In deciding what to include as Essentials of the Refraction and Diseases of the Eye, the writer has been guided by an acquaintance, gained in post-graduate teaching, with the needs and desires of the mass of medical graduates. For until the time of undergraduate study is extended, and ophthalmology made a compulsory branch of undergraduate instruction, but few will give it much attention during that period. A fair acquaintance with the general principles and facts of medicine and surgery is therefore presumed, and starting from this, the attempt is made to introduce the student to the essentials of this branch. It is also borne in mind that points of anatomy and physiology are given in other volumes of this series, which must be consulted, if their contents be not already stored for mental reference.

In the relative proportions of space assigned to different subjects there are great departures from the average of text-books extant. The capital operations of ophthalmic surgery are but briefly noticed, and subjects of great interest to the advanced special student are passed unmentioned. This is done that the space may be kept for that which is of most importance to the student, who, though well advanced in the study of certain departments of medicine, may be a tyro in this. It is not hoped that all will be satisfied with what can be learned here; but that those who go farther shall find here a good foundation for future progress; and that those who cannot extend their studies in this direction will find the satisfaction of their more urgent needs.

The student cannot be too strongly urged to combine with his reading a study of the laws of refraction, as they can be illustrated with a magnifying glass and piece of card-board; and of the appearance of his own normal eye, with a mirror. And if he can get a single normal fundus to study with the ophthalmoscope every day for a month, he has the best opportunity in the world for beginning the use of that instrument.

EDWARD JACKSON.

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ESSENTIALS OF REFRACTION.

What is the purpose of the refraction of the eye?

To assort the light which enters the eye so that each point of the retina can receive light from only one point outside the eye, and transmit a single distinct impression.

What are the dioptric media of the eye?

A dioptric medium is any transparent substance. Those of the eye are the cornea, aqueous humor, crystalline lens, and vitreous humor. The normal retina also is transparent.

What is the index of refraction of a transparent substance?

It is the number indicating the relative length of time that it takes light to travel a given distance in that substance. Light travels faster in some transparent substances than in others; it travels fastest in a vacuum, but very nearly as fast in air. If we take the time required to travel a certain distance in air as one, the times required to travel the same distance in other transparent media, or the indexes of refraction of these media, would be as follows:

Water, the cornea, or the aqueous or vitreous humors	1.33
The crystalline lens	1.45
Crown glass, used for spectacles	1.53
Rock crystal, "pebble"	1.56
Flint glass	1.70
Diamond	2.60

What is a dioptric surface?

Any smooth surface separating transparent substances having different indexes of refraction is a dioptric surface.

What is the refraction of light?

The change in the direction of its movement that occurs whenever it passes obliquely through a dioptric surface. In Fig. 1, A–B represents a ray of light piercing obliquely the

dioptric surface of a piece of glass at B, and at that point bent from its original direction to the direction B–C. At C again it passes obliquely through the other surface, and is bent in the other direction. When a ray pierces a dioptric surface perpendicularly, as the ray H–K, it is not refracted; when it passes obliquely from a less refractive to a more refractive medium it is bent *toward* the perpendicular P–P; when it passes obliquely from a more refractive to a less refractive medium it is bent *from* the perpendicular. The extent to which light

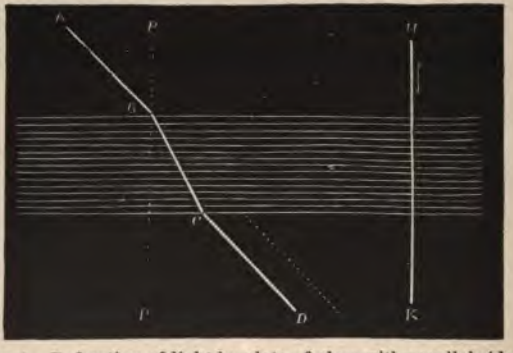

FIG. 1.—Refraction of light by plate of glass with parallel sides.

is refracted depends on the obliquity with which it strikes the dioptric surface, and on the difference between the index of refraction of the substance *from* which it passes and the index of refraction of the substance *to* which it passes.

How is light refracted when it passes through a piece of glass with parallel surfaces?

On entering the glass it is bent *toward* the perpendicular, but on leaving the glass it is bent, to an equal extent, *from* the perpendicular, so that its direction after leaving the glass is parallel to its direction before entering it (see Fig. 1).

What is a prism?

It is a portion of some transparent medium—for our purposes glass—bounded by plane surfaces that are inclined to one another. The inclined surfaces are called the *sides* of the

prism, the angle at which the sides come together is the *refracting angle*, the part of the prism opposite the refracting angle is its *base*.

How is light refracted by passing through a prism?

It is always refracted toward the base of the prism (see Fig. 2). The ray is bent toward the perpendicular where it enters the prism, and, after passing through the glass, is bent from the perpendicular on passing out, the total effect being to bend it toward the base of the prism.

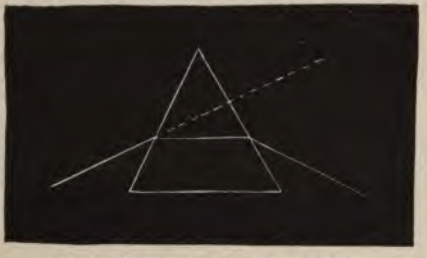

FIG. 2.—Refraction of light by a prism.

What determines the strength of a prism?

The size of its refracting angle, and the difference between the index of refraction of the glass of which it is made and the index of refraction of the air around it. A prism is said to be strong when it turns the light very much from its original course, and weak when it changes its direction but little.

How are prisms numbered?

In the old system, still in common use, by the number of degrees in the refracting angle; in the new system, by the *centrads* of deviation they cause in the direction of the rays passing through them. The numbers are practically the same by both systems. The prism having a refracting angle of one degree produces almost one centrad of deviation.

What is a spherical lens?

A portion of a dioptric medium bounded by smooth surfaces, one or both of which are spherical. The word lens,

where used alone, is to be taken as meaning spherical lens, unless otherwise indicated.

What is a convex lens?

One that is thickest at the center. It is indicated by the sign +.

What is a concave lens?

One that is thinnest at the center. It is indicated by the sign —.

What are the different kinds of convex and concave lenses?

1. Planoconvex, plane one side, convex the other.
2. Double or biconvex, both sides convex.
3. Concavoconvex, one side concave, the other more convex.

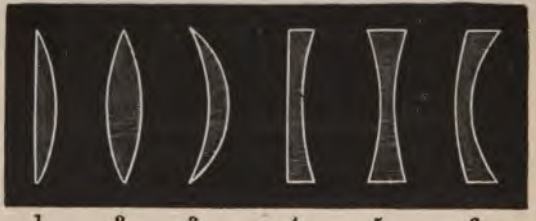

FIG. 3.—Different forms of lenses.

4. Planoconcave, one side plane, the other concave.
5. Double or biconcave, both sides concave.
6. Convexoconcave, one side convex, the other more concave.

3 and 6 are also known as *periscopic* or *meniscus* lenses. These different forms are shown in Fig. 3, the first three being convex, the last three concave. (See also pp. 40, 42, and 47.)

What is the optical center of a lens?

The point at which the opposite surfaces of the lens are parallel. A lens may be regarded as made up of a series of prisms, which are weakest nearest to the optical center and increase in strength as you go from the optical center. In the convex lens these prisms are placed with their bases

toward the optical center; while in the concave lens they have their bases turned *from* the optical center.

How does a convex lens refract the light passing through it?

The optical center, acting as a glass plate with parallel sides, does not change the direction of the rays that pass through it. The rays that pass near the optical center, being affected as by weak prisms with the base toward the optical center, are turned a little toward the center. Those rays piercing the lens somewhat farther from the optical center encounter a somewhat stronger prism with its base turned the same way, and are, therefore, more decidedly bent toward the center. Those still farther removed from the central ray, passing where the lens acts as a still stronger prism are bent yet more toward the central ray. In general throughout the lens, the farther a ray is from the center the more it is turned toward the central ray. Hence the rays from all parts of the

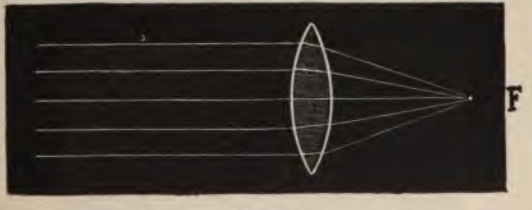

FIG. 4.—Focussing of light by a convex lens.

lens are so turned in as to intersect the central ray some distance back of the lens. Fig. 4 illustrates the effect of a convex lens on parallel rays of light falling upon it; they are all made to intersect the central ray at F. If, however, the light starts from the point F, and falls upon the lens, the central ray, as before, is not refracted, while the others are all bent toward it in such a way that after passing through the lens they will all be parallel. The rays are equally refracted whichever direction they pass through the lens.

What is a real focus?

It is a point at which the rays that have all started from a

single point are brought together again, as by the action of a convex lens. When, as in Fig. 4, the rays which fall upon the lens are parallel, they are regarded as all coming from one point, which is situated at an infinite distance. This point at which the lens brings parallel rays to a focus is called the *principal focus* of the lens. When we speak of the focus of a lens without any qualifying word it is to be understood that the principal focus is meant.

How does a concave lens refract light?

The ray passing through the optical center is not refracted; the other rays are all turned from it. The concave lens is also to be regarded as a series of prisms, the weakest near the center, the strongest farthest removed from the center. But in this case the prisms have their bases all turned from the center, and the effect is to scatter the light, not to concentrate it. In Fig. 5 the effect of the concave lens is shown. After passing through the lens the rays diverge as though they had originally started from the point F.

FIG. 5.—Concave lens turning rays from its focus.

What is a virtual focus?

Such a point, from which rays appear to be diverging after passing through a lens, is called a virtual focus. It is a point from which rays appear to diverge that in reality start from some other point. When rays previously parallel are refracted by a concave lens, the point from which they appear subsequently to diverge is a *principal focus* of the lens. Thus F is the principal focus of the lens in Fig. 5.

What is the focal distance of a lens?

The distance from a lens to its focus. It is also called the

focal length of the lens. The distance from a lens to its principal focus is its *principal focal distance* or length; and this is what is generally meant when the focal distance of a lens is mentioned.

What determines the strength of a lens?

A "strong" lens is one that can make a great change in the direction of the rays passing through it and bring them quickly to a focus. The farther the rays have to travel after passing through the lens before they come to a focus the weaker the lens; the strength of a lens is inversely as its focal distance. Now, in order that the rays may be quickly turned in to the focus, the inclination of the sides of the lens to each other, or from each other, must increase rapidly as you go from the optical center toward the margin. The strength of a lens, therefore, depends on the curvature of its surfaces; it also depends on the differences between the index of refraction of the substance of which the lens is made and the index of refraction of the air.

How are lenses numbered by the inch system?

Each lens is designated by the number of inches in the radius of curvature of its equally curved surfaces if it is a biconvex or biconcave; or if it is of one of the other shapes it is given the number of the biconvex or biconcave lens of the same strength. Formerly most trial-sets were made in Paris and given the number of the Paris inches in their radii of curvature; and it happened that the glass of which they were made had such an index of refraction as to make the focal distance of the lens in English inches about the same as the radius of curvature in Paris inches. Hence the number of the lens has very generally been taken as indicating the number of inches in its focal distance.

How do you express the strength of a lens numbered on the old or inch system?

By a common fraction in which the numerator is 1 and the denominator is the number of the lens; that is, the strength of the lens is just the inverse or reciprocal of the number which expresses its focal distance. It will be noticed that the different fractions expressing the strengths of different lenses

will all have different denominators. Hence, in adding or subtracting these lenses whenever they were to be combined one with another, we always had to work with fractions that required to be reduced to a common denominator.

How are lenses numbered by the new metric or dioptric system?

A lens that brings parallel rays to a focus at a distance of one meter is taken as the unit and called a one-diopter lens, written 1 D. A lens twice as strong is called the two-diopter lens, one three times as strong, a 3 D. lens, and so on; the number of the lens expressing its strength. For lenses weaker than one diopter, and for those intermediate between whole diopters, decimal fractions are used, as 0.50 D. or 2.75 D. Hence, when lenses numbered on this system are combined, we have only to do with the addition or subtraction of whole numbers and decimal fractions.

How do the numbers given to the same lens by these different systems of numbering compare with one another?

In the following table the first column gives the number of the lens according to the dioptric system, the second column gives the focal distance in English inches of its exact equivalent, and the third column gives the nearest equivalent, as inch lenses are commonly made:

Diopters.	Focal dist.	Old No.	Diopters.	Focal dist.	Old No.
0.25	157.5	144	6.	6.6	6½
0.50	78.7	72	7.	5.6	5½
0.75	52.5	48	8.	4.9	5
1.	39.4	36	9.	4.4	4½
1.25	31.6	30	10.	3.9	4
1.50	26.2	24	11.	3.6	3½
1.75	22.5	22	12.	3.3	3¼
2.	19.7	20	13.	3.	3
2.25	17.5	18	14.	2.8	2¾
2.50	15.7	16	15.	2.6	
2.75	14.3	14	16.	2.4	2½
3.	13.1	12	17.	2.3	
3.50	11.2	11	18.	2.2	2¼
4.	9.8	10	19.	2.1	
4.50	8.7	9	20.	2	2
5.	7.9	8	25.	1.5	
5.50	7.2	7	30.	1.3	

What is the trial-set?

A collection of glasses for testing the optical conditions of the eye, including pairs of the convex and concave, spherical lenses given in the preceding table, the same numbers of cylindrical lenses up to 6 D., prisms, solid disk to exclude one eye when testing the other, a pin-hole and stenopaic disks, colored glasses, and a trial frame in which any of these may be placed before the eye. Sets containing fewer lenses can be used by combining two or more lenses together. The lenses are usually biconvex and biconcave 1.5 inches in diameter. Plano lenses are preferable, and they may be 1.25 inches in diameter.

How would you ascertain the strength of any lens?

By finding what lens in the trial-set exactly neutralized it; this would be a lens of the opposite kind, but having the same number as the lens tested. When a convex lens is held a little before the eye, and moved slowly up and down or from side to side, distant objects seen through the lens appear to move in the opposite direction. When the same thing is done with a concave lens, the distant objects appear to move in the same direction as the lens. When, however, we place together a convex and a concave lens of equal strength, and move them thus, the objects seen through them appear to remain fixed in their proper position, just as though seen through a piece of plane glass. The absence of motion proves that the lenses exactly neutralize.

REFRACTION OF THE EYE.

What are the important dioptric surfaces of the eye?

The anterior surface of the cornea, the anterior surface of the lens, and the posterior surface of the lens.

How do these surfaces refract light?

As so many convex lenses, and their total effect is that of a very strong convex lens. One ray falling perpendicularly on the cornea is not refracted, while all the other rays coming from the same point are bent toward it, and made to intersect it at a focus a certain distance back of the cornea.

What is the effect of this focussing of the light?

All the light that enters the eye from any one point outside it is collected to a single point within it. Thus in Fig. 6 the rays coming from the point *A* are all focussed at the point *a* within the eye; in the same way all the rays coming from the point *B* are focussed at the point *b*. This same focussing of rays will happen for any number of points situated between these, or on either side of them. Now if the sensitive retina, on which the impressions of light are made, be so situated that these foci fall exactly upon it, each point of the retina will receive all the light from one point outside the eye, and from that point alone; it will therefore transmit to the brain a distinct impression made by that particular point, and the brain thus receiving separate messages from each point of surrounding objects is able to discriminate between the different ones presented to the eye at the same time. If, however, the retina be so situated that the rays are not perfectly focussed upon it, it receives impressions that are not perfectly assorted, but run into each other.

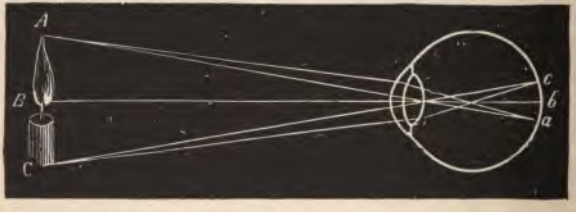

FIG. 6.—Formation of image within the eye.

What determines the acuteness of vision?

The sensitiveness of the retina and connected nervous apparatus, and the perfection of the focussing of the light on the retina. When one of these is constant, the acuteness of vision becomes the measure of the other.

How do you ascertain and record the acuteness of vision?

The size of the image on the retina is proportional to the size and inversely proportional to the distance of the object looked at. This may be understood from an examination of

Fig. 7, in which *A–B* and *C–D* represent objects of the same size at different distances from the eye. Series of test-type of different sizes are prepared, and each size is marked with the distance it should be seen by a perfect eye in good light. We use these by finding what is the smallest type that can be seen at a certain distance; and then by a fraction, of which the distance at which the type *is seen* is the numerator, and

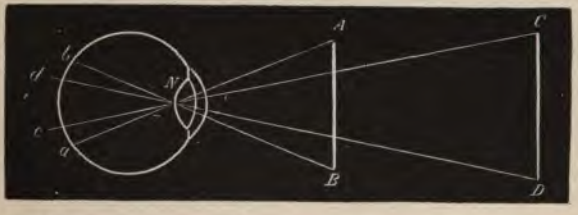

FIG. 7.—Size of images from the same objects at different distances.

the distance it *should be seen by a perfect eye* is the denominator, we express the acuteness of vision. Thus, if the types are seen at fifteen feet, and the smallest that can be made out at that distance is that which should be visible at forty feet, the acuteness of vision is $\frac{15}{40}$.

When do we have divergent, parallel, or convergent rays?

These terms, as we use them, always refer to rays coming from the same point, and rays always diverge from a luminous point in every possible direction, and continue in their divergent course so long as no change occurs in the medium through which they pass, so that in nature we encounter only divergent rays; the more distant the point from which they come, the less divergent will be the rays that fall upon any given area, as the surface of a lens or the pupil of the eye. Rays coming from an infinite distance would be strictly parallel, but if they come from a distance of fifteen or twenty feet or over they are so nearly parallel that we may call them parallel without serious error, and shall hereafter speak of them as parallel rays. Rays are rendered convergent by passing through a convex lens or by being reflected by a concave mirror.

What is the refraction of the eye?

Its optical state with reference to parallel rays when the crystalline lens is least convex or weakest, as it is when under the influence of atropin or as it would be immediately after death.

What is the accommodation of the eye?

The power of changing the optical state of the eye by making the crystalline lens more convex, causing it to act as a more convex or stronger convex lens, and thus increasing the total refractive power of the eye.

When is an eye emmetropic?

When its retina is just far enough back from the cornea and crystalline lens to have perfectly focussed upon it rays that have reached the eye parallel, the accommodation being entirely at rest. This position of the retina is shown in Fig. 8, at E. *Emmetropia* (proper proportions) is the name given to the state of refraction in such an eye; it is often represented by the abbreviation E.

When is an eye hyperopic?

When its retina is too near the cornea and lens and the light falls upon it before it is focussed, the accommodation

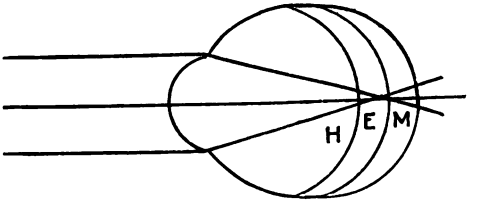

FIG. 8. Relation of the retina to the focus for parallel rays in hyperopia, emmetropia, and myopia.

being at rest. Such a position of the retina is indicated at H in Fig. 8. The state of refraction in such an eye is called *hyperopia* or *hypermetropia;* it is represented by the letter H.

When is an eye myopic?

When its retina is too far back from the cornea and lens,

so that rays which enter the eye parallel are focussed before they reach it. Such a position of the retina is shown at M, Fig. 8; its state of refraction is *myopia*, represented by the abbreviation M.

What is ametropia?

This is a general term, including all states of the refraction of the eye that differ from emmetropia. The emmetropic eye is to be regarded as the standard or perfectly formed eye; and all departures of the refraction from the emmetropic standard are spoken of as *errors* or *anomalies of refraction.*

Why does the eye require the power of accommodation?

Rays enter the eye with different degrees of divergence, proportioned to the nearness of the object from which they come; the more divergent rays need to be turned more from their original course, they require a lens of greater refractive power to focus them. Hence the need to be able to render the crystalline lens more convex when the more divergent rays from near objects are to be focussed on the retina.

How is the crystalline lens rendered more convex?

In the condition of rest it is flattened by tension of the fibres of the zonule. Contraction of the ciliary muscle takes the tension of the zonule off the lens, permitting it to become more convex by reason of the elasticity of the lens fibres. The increase of curvature occurs chiefly at the anterior and posterior poles of the lens, the part exposed in the pupil. The convexity of the more peripheral portions of the lens is less increased or they may be actually flattened. This diminishes the positive or increases the negative aberration of the eye.

What is the near point?

When the ciliary muscle is contracted to the full extent of its power, the lens becomes the most convex that it ever can, and focusses rays the most divergent that it is ever able to focus on the retina. The point from which these rays diverge is the near point of distinct vision; it is often called the *punctum proximum*, and indicated by the abbreviation *p.p.* Rays coming from points beyond *p.p.* are focussed on the retina by less contraction of the ciliary muscle.

How do you determine the near point?

Take test-type prepared for the purpose and hold them first at a distance at which they are read most easily, then, while the patient continues to read them, bring the type progressively nearer to the eye, until he can no longer see them clearly. The nearest point at which they are clearly read is the point desired. In making this test care must be taken that the type are so small as to require perfect focussing in order that they should be seen at this distance, and the patient must be induced to make the effort and exert his whole accommodative power.

What is the amplitude of the accommodation?

The extent to which the exertion of the full power of the ciliary muscle is able to change the focussing power of the crystalline lens. It is usually expressed in diopters, the strength of the equivalent convex lens. It depends on the power of the ciliary muscle and the flexibility of the lens.

What cause paralysis of accommodation?

Cycloplegic drugs like atropine, acute diseases, especially diphtheria, chronic degenerative disease of the central nervous system, and reflex influences, especially from nasal disease.

How is the accommodation affected by age?

The lens grows year by year less flexible, gradually losing its power of becoming more convex upon contraction of the ciliary muscle; until it becomes so rigid that the attempt is no longer made to change its shape, and the muscle atrophies. The following table shows how the amplitude of accommodation diminishes with age. From these averages individuals may vary widely.

Years.	Diopters.	Years.	Diopters.
10	14.	40	5.5.
15	12.	45	4.
20	10.	50	2.5.
25	9.	55	1.5.
30	8.	60	0.5.
35	7.	65	0.

What proportion of the accommodation is available for continuous near work?

About two-thirds of the whole. If an effort is made to exert more than this, much of the time, the ciliary muscle and nerves governing it are over-fatigued and symptoms of eye-strain appear.

What is presbyopia?

The diminution of the power of accommodation by age to such an extent as to interfere with the ordinary use of the eyes for reading, writing, sewing, and similar near work.

When does presbyopia usually occur?

Between forty and fifty years of age. Reading, writing, etc. are ordinarily done at a distance of from twelve to eighteen inches, requiring the use of 2 D. or 3 D. of accommodation; and when the total accommodation has so far diminished that this would be more than two-thirds of it, the trouble begins.

What are the symptoms of presbyopia?

One of the first is a tendency to hold reading matter further from the eyes than has previously been the custom; things requiring particularly accurate vision, as threading a needle, or reading very fine print, can no longer be done, except in a very good light. After the use of the eyes for close work for a time the thing looked at is apt to become dim, and it is necessary to rest the eyes for a little time. Or there is pain or headache after the use of the eyes for near work, or the eyes become congested, or even inflamed, after such work; such inflammation is often ascribed to "cold."

What is the remedy for presbyopia?

The use of the proper convex lenses for all near work. The lens will do a part of the work which would otherwise all devolve on the accommodation. It should be strong enough to render it unnecessary to use over two-thirds of the remaining accommodation.

How often should the glasses be changed in presbyopia?

While the accommodation is still diminishing, they should

be changed at least once every two or three years; but after the power of altering the form of the crystalline lens is pretty much lost, as after the age of fifty-five, they may not need changing for a long time.

FIG. 9.—The ophthalmoscope.

THE OPHTHALMOSCOPE.

Why does the pupil of the eye ordinarily appear black?

The focussing or assortment of the light that enters the eye allows one part of the retina to be brilliantly lighted up, while another part is in comparative darkness. When one looks into another's eye the part of the retina he might see if it were lit up is the part that can get light only from the direction of his own pupil, and which, therefore, is receiving very little light at that time.

What is the ophthalmoscope?

An instrument having a mirror to throw light into the interior of the eye, and a hole in the mirror, through which the observer can look and see an illuminated part of the retina; the mirror is usually concave, so as to concentrate the light in the pupil; the margin of the sight-hole should be carefully blacked to avoid confusing reflections from it.

What is a refraction ophthalmoscope?

One in which a series of convex and concave lenses are placed back of the mirror in such a way that either of them can be brought to the sight-hole, for the measurement of the

various forms of ametropia. As it has to be used very close to the eye, it should have the mirror so attached that it can be inclined either to the right or left. It should be possible to use all the lenses without having to take the instrument from the eye to change them.

Fig. 9 shows a form suggested by the writer. It has the lenses arranged in two slides moved by milled projections at their lower ends, and by combinations furnishes convex 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 7.5, and 10 diopters, and concave 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 15, and 25 diopters; these constitute a series sufficient for all practical purposes, and they are all available without removing the instrument from the eye.

What is the direct method of ophthalmoscopic examination?

That in which the observer looks directly at the interior of the eye under observation, very much as one might look at any small object through a strong magnifying glass.

What are the relative position of surgeon and patient for such an examination?

They sit side by side, but facing in opposite directions. The lamp is behind the patient, not immediately back of him, but rather to the side of the eye to be examined—that is, in front of the surgeon, so that the light from it shines on the patient's temple and just touches the tips of the outer lashes. To examine the patient's right eye the surgeon sits on the patient's right, holds his ophthalmoscope in his own right hand, and uses his own right eye; while for the left eye he sits on the patient's left and uses his own left eye and hand; this must be done in order to get near the eye to be examined. When thus arranged the ophthalmoscope is held so as to reflect the light from the lamp into the patient's pupil while the surgeon looks through the sight-hole. The area of light reflected on the patient's face will have the shape of the ophthalmoscope mirror, with a dark spot in the center corresponding to the sight-hole; this gap, caused by the sight-hole, must be made to fall about on the pupil before the interior of the eye will be well lit up.

What is the fundus reflex?

A general red glare that seems to fill the pupil on first throwing the light into an eye with the ophthalmoscope.

What can be seen with the ophthalmoscope?

The transparent media of the eye are normally as invisible as the air. The retina, too, is normally almost perfectly transparent, and in eyes with a light fundus is also quite

FIG. 10.—Fundus of an eye containing little pigment; choroidal vessels visible (Wecker).

invisible; in eyes with a very dark choroid it appears like a faint gray veil. The layer of pigment-epithelium, belonging with the retina, though often spoken of as part of the choroid, partly determines whether the general hue of the fundus shall be light or dark by the amount of pigment it contains; and also to what extent the choroid back of it shall be visible. When there is little pigment in this membrane, the larger choroidal vessels are seen through it, forming a network with interspaces that are light if the choroid also is deficient in pigment, or dark when it is more deeply pigmented; if the retinal pigment and that of the choroid are both quite lacking, one sees the white sclera.

What is the optic disk?

It is the ocular end of the optic nerve; sometimes it protrudes a little into the vitreous humor; it is often called the optic papilla. Generally there is in its center a depression known as a *physiologic cup*, or cupping of the disk; this is the whitest part of the disk; around it is a pinker zone. The whole disk is lighter colored than the rest of the fundus, approaching it in color in very light eyes, but contrasting very sharply in eyes that are darkly pigmented; around the disk there is generally an incomplete ring of darker brown color, due to an accumulation of pigment in the margin of the choroidal foramen through which the nerve-fibers are admitted to spread out on the retina.

FIG. 11.—Normal optic disk of the left eye (after Jaeger).

Describe the appearance of the retinal vessels.

They are darker red than the general fundus, the veins being darker than the arteries, and of a more crimson hue. They come into view a little to the nasal side of the center of the optic disk, generally as several branches; and the larger branches pass upward and downward, the majority of them curving toward the temporal side of the retina.

How do you measure the refraction of the eye with the ophthalmoscope?

Looking into the eye by the direct method, the different lenses are one after another tried before the sight-hole until one is found which makes the details of the fundus distinct,

when neither the surgeon nor the patient are using any accommodation; in doing this it is best to look at some of the fine vessels to the temporal side of the disk, between the disk and the macula.

How are the patient and surgeon to secure relaxation of the accommodation?

The patient must look off and allow his gaze to rest on some dark curtain or shadow where the use of his accommodation would not enable him to see anything distinctly; on this account the room for such an examination should not be very small and should be thoroughly darkened. The surgeon, too, must look as though at some distant object; the power of doing this whenever desired is only to be acquired by much practice.

If more than one lens renders the details of the fundus clear, which is to be chosen?

The strongest convex or the weakest concave is the nearest right. If the observer's eye is emmetropic, or his ametropia corrected, this is the glass the patient needs; otherwise allowance must be made for the observer's ametropia.

What is the indirect method of ophthalmoscopic examination?

The surgeon keeps his eye a foot or more away from the patient's eye, in front of which he holds a strong convex lens; the lamp is placed back of the patient, but the surgeon can examine both eyes while sitting on one side of the patient or directly in front of him. When the retina has been lit up by the light reflected into the eye by the mirror, the light which emerges from it is focussed by the convex lens, so that it forms an inverted aërial image in front of the lens, and it is at this inverted image that the surgeon looks, as in the direct method he looked at the retina itself.

What are the respective merits of the direct and indirect methods?

The former shows the parts in their true relative positions, gives a more magnified view of the retina, allows the estimation of the state of refraction, and, by differences of refraction, permits us to measure the relative protrusion (as in neuritis)

or recession (as in glaucoma) of various parts of the fundus. The indirect method merely allows us to see a larger part of the interior of the eye at one glance, the image being less magnified, but it does not compel one to get so near the patient's face; it is less valuable, and is coming to be less used than the direct method.

When can the inverted image of the fundus be seen without any convex lens?

When the eye is myopic, the rays from the retina are focussed in front of the eye, at the distance from which rays would be focussed on the retina; at this distance, therefore, an inverted image of the fundus is formed; thus, in Fig. 12,

FIG. 12.—The focus conjugate to the retina, or point of reversal.

the image of A is formed at *a*, while that of B is formed at *b*, and by drawing back from the eye beyond this distance the inverted image can be seen. When the eye is highly myopic, it is easy to examine the inverted image thus formed without any convex lens.

What is the point of reversal?

It is the point at which this inverted image is formed. Closer to an eye than this its fundus is seen erect; beyond this the inverted image is seen.

What is the shadow-test, skiascopy, or retinoscopy?

A method of finding the point of reversal by throwing light into the eye from a mirror, and by turning the mirror and so causing the light to move about in the eye; and then, knowing the direction of its real motion and noticing the direction of its apparent motion, ascertaining whether the erect or the inverted image is seen. By trying this at different

distances and with different lenses, we find out where the reversal occurs, and this point of reversal, being the point for which the eye is focussed, gives us the amount of myopia.

How does the light really move on the retina with the plane mirror?

With the mirror; that is, in the same direction as the light area that moves across the face. This is true whether the eye is myopic, hyperopic, or emmetropic.

How does the light in the pupil appear to move in myopia?

Closer to the eye than the point of reversal it appears to move *with* the light on the face; beyond the point of reversal, in the opposite direction from that of the light on the face; *against* the light on the face. At the point of reversal the illumination becomes very faint in the center of the pupil and destitute of motion, although the edge of the pupil may present a bright reflex with a very distinct motion.

How do you determine the amount of myopia?

The point of reversal is the point for which the eye is focussed; its distance from the eye, which can be measured by the meter-stick or tape, is the focal distance of the lens required to correct the myopia; thus, if the reversal occur at a half-meter, there are 2 D. of myopia; if at one-seventh of a meter, 7 D. If we find that the myopia is high, it is best to correct part of it by placing a concave lens before the eye, then measure the remaining M., and add it to the strength of the lens used to find the total M.

How does the light in the pupil appear to move in hyperopia?

Always *with* the light on the face, because the rays that come out of an hyperopic eye do not converge and are not focussed at any distance in front of the eye.

How do you determine the amount of hyperopia?

Place in front of the eye a convex lens that is strong enough to over-correct the hyperopia, and measure how much myopia this lens causes; then, subtracting this from the whole strength of the lens, the remainder will be the amount of hyperopia.

How do you determine the presence of emmetropia?

The rays emerging from the eye parallel do not come to a focus. So that at all distances the light in the pupil appears to move *with* the light on the face, but on placing a convex lens before the eye, the point of reversal is found to coincide with the principal focus of the lens, the amount of myopia caused by the lens being just equal to its strength.

How does the light move when the concave mirror is used?

The light area on the retina really moves in the direction opposite to that of the light on the face; its apparent motion in the pupil is, therefore, just the opposite of the apparent motion with the plane mirror under similar circumstances. Thus, in myopia, from beyond the point of reversal the apparent motion is *with* that of the light on the face; while in hyperopia and emmetropia, and in myopia, when closer to the eye than the point of reversal, the apparent motion is *against* that of the light on the face.

How else is the shadow-test modified by the use of the concave mirror?

It is not practicable with the concave mirror to vary the distance from the eye under observation; hence a certain distance is chosen, usually about one meter, and by trying different glasses the point of reversal is brought to this distance. The glass that does this leaves the eye with one diopter of myopia; and to get the glass which will just correct the ametropia present and give perfect distant vision, the glass used must have one diopter added to its strength if it is concave or subtracted if it is convex.

What are the conditions of accuracy with the shadow-test?

The pupil must be sufficiently large, the room thoroughly darkened, the source of light brilliant but small (a lamp-flame enclosed by an opaque metal chimney, in the side of which is a circular opening four millimeters in diameter, is a good source), a small sight-hole in the mirror, free from reflexes; and a lens before the eye that will bring the point of reversal to a distance of one-half meter or less from the eye.

HYPEROPIA.

What are the advantages of an emmetropic eye?

It can see all distant objects clearly without any exertion of its powers of accommodation, and has all of its accommodative power available for the focussing of light from close objects.

What are the disadvantages of the hyperopic eye?

It cannot in a state of rest see clearly at any distance; for even parallel rays it must use some of its power of accommodation, and therefore it has so much less focussing power left for overcoming the divergence of rays from near objects.

What is the absolute hyperopia?

When the H. is greater than the amplitude of accommodation, the accommodation is not able to correct all of it; the part that remains uncorrected after all the accommodation has been exerted is called the *absolute hyperopia;* it is generally present when the power of accommodation has been diminished by age.

What is latent hyperopia?

When a young person has to use a certain amount of accommodation to see even distant objects clearly, he frequently is unable to relax his accommodation entirely when looking at distant objects, even when this is not required for clear vision. The portion of the accommodation thus unrelaxed neutralizes and so conceals an equal amount of H., which is therefore called *latent hyperopia.*

What is manifest hyperopia?

All hyperopia that is not latent.

What is facultative hyperopia?

The part of the manifest hyperopia that can be corrected by accommodation or left uncorrected at will.

What is the total hyperopia?

The sum of the other varieties; that is, the latent plus the manifest.

What are the evidences of hyperopia or far sight?

Distant vision is generally distinct until about the age of fifty, after that it is more or less indistinct. Near vision is more difficult or imperfect; the symptoms of presbyopia come on early, sometimes even in childhood. Headache is very often due to hyperopia; it may be constant or felt only after use of the eyes for near seeing. Chronic or recurrent congestion or inflammation of the eye or its appendages is produced by H. All the symptoms are worse in proportion to the amount of work the eyes are required to do. On testing the eyes, the near point is found too far from the eye for the age of the patient, and the distant vision is improved, or at least not seriously impaired, by convex lenses.

What should be done for hyperopia?

The strongest convex lens should be worn that allows clear distant vision; the most benefit will be derived by wearing the lens constantly, but in some cases the help received by wearing it for near work alone will be sufficient to give relief from all the symptoms complained of, and may be all that is necessary. If the selection of the lens is made by looking at test-type about four meters from the eye, the lens chosen will be too strong for very distant vision by about 0.25 D., and this amount should be subtracted from its strength in ordering a distance-glass. If the H. has been measured when the eye was under the influence of a mydriatic, it will often be found in persons under fifty that after the effect of the mydriatic has passed off some of the H. has become latent, and that the lens is too strong to allow clear distant vision. If, however, the glass is worn, this latent H. will in a few days or a few weeks become manifest, and distant vision clear. It is therefore best, as a rule, to give the correcting lens of the full strength, warning the patient of the temporary difficulty, and promising its gradual decrease and disappearance.

What are the mydriatics or cycloplegics?

A group of drugs—atropin, daturin, duboisin, hyoscyamin, and homatropin—that when instilled into the eye dilate the pupil and render it inactive to light and paralyze the accommodation. They also have a powerful toxic action;

but homatropin are liable to cause dryness of the throat, flushing of the skin, and the ordinary symptoms of intoxication. (For methods of using these and euphthalmin, see formulas at end of book.)

What are the objections to the use of a mydriatic?

It may precipitate an attack of glaucoma in an eye already upon the verge of such an attack. The danger of an eye being in such a condition is very slight under the age of forty, but a careful search for symptoms of glaucoma should always precede the use of the drug. Mydriatics will, in a few persons, cause a conjunctivitis, but commonly only after a somewhat prolonged use; the inconvenience of being deprived of the power of accommodation is reduced to a minimum by the use of homatropin, recovery from which is generally complete within two days.

MYOPIA.

How is myopia recognized?

The myopic eye is "near-sighted." Eyes with imperfect vision from any cause are liable to be called near-sighted, because they can see objects close to them that they could not distinguish at a distance. But the really myopic eye can see a near object better even though it be proportionately smaller; thus, it may not be able to see the 200-feet type at 20 feet, yet read easily the 10-inch type at 10 inches. If the myopia is of high degree, the eyeball, when turned in strongly toward the nose, is seen to be somewhat elongated. On testing, the near point is found to be closer to the eye than would be expected from the age, and concave lenses improve distant vision.

What are the disadvantages of myopia?

Vision is imperfect for all objects that are not very close to the eye; even with so little as one diopter, nothing is clearly seen beyond arm's length; this incapacitates the myope for many kinds of business and pleasure, and renders him very liable to accidents of various kinds. When the myopia is of high degree, close work even, like reading or sewing, must be held inconveniently near the eyes, or the

head must be bent down to the work in order to see clearly; then, in order that both eyes may be turned toward the same point, they must be made to converge very much, causing strain of the internal recti muscles, and, if this strain is great, the effort to see with both eyes is generally given up and a divergent squint is the result.

What are the dangers of myopia?

It tends to increase; this is due to congestion and inflammation of the coats of the eye, particularly the choroid, with the increased fulness of the eyeball and the softening of the coats that attends congestion. But the myopia, by preventing distant vision, favors reading and similar occupations that produce congestion; and the excessive effort to turn the eyes in, and the bending the head forward to see clearly, increases it. Then, too, when the coats of the eye have already been somewhat over-distended, they are thinned and give way more readily before the distending force. The tendency to increase of M. is greatest in childhood; if once checked, it may not return during adult life. High degrees of myopia are almost invariably attended wtth serious damage to the choroid, which is liable to affect the tissues depending on it for their nutrition—the vitreous humor and the crystalline lens. Hence, myopic eyes are very liable to cataract, opacity of the vitreous, or detachment of the retina; even if these are escaped, the sensitiveness of the retina is impaired, so that even at short distances or with the best correcting glasses, vision is very imperfect.

What is to be done for myopia?

Concave lenses correcting the myopia are to be worn and excessive use of the eyes avoided. For all but very high degrees of myopia, or M. with imperfect vision from choroidal disease or other causes, the lenses correcting all the myopia should be worn. For very high M. it is sometimes better to leave a little of it uncorrected. When the patient is young, having sufficient power of accommodation, the same lenses should be worn constantly for near and distant vision. When the patient is presbyopic, weaker lenses, adjusted to the amount of presbyopia, are required for near work. The kind and

amount of eye-work to be done must be controlled by its effect on the eyes.

What is the surgical treatment for myopia, and when should it be used?

The removal of the clear crystalline lens. This is accomplished by repeated needling, causing absorption, in young patients, and by extraction of the lens in older persons; it renders the eye very much less myopic or more generally hyperopic. This does away with the need of strong concave lenses and, by giving larger retinal images, increases the acuteness of vision; it is applicable to cases having over 15 D. of M., and capable of fair vision when this is corrected.

ASTIGMATISM.

What is astigmatism?

That defect of the eye that causes rays not to be focussed to a point as by a spherical lens, but into one or more lines, causing a point of light, as a star, to appear as a group of lines.

What is regular astigmatism?

The error of refraction caused by inequality of the curvature of the refracting surface in different directions, the curve being somewhat like that of the edge of a watch or the bowl of a spoon. Usually it is the surface of the cornea that is at fault, but the astigmatism may be due to the lens; obliquity of the lens to the visual axis will cause this defect of refraction. Regular astigmatism is the kind of greatest practical importance, and it is customary to designate it simply as astigmatism; the term "irregular" is used when the other kind of astigmatism is meant.

How does the astigmatic deformity of the cornea occur?

Usually it is congenital; in a small proportion of cases it gradually develops during childhood or adult life; it may also be produced by disease or injury of the cornea, as corneal ulcer, pterygium, etc.; it occurs after all operations, as cataract extraction or iridectomy, which involve an extensive corneal incision.

What are the principal meridians of regular astigmatism?

The direction in which the cornea curves most—the *meridian of greatest refraction*—and the direction in which it curves least—the *meridian of least refraction.* In so far as the astigmatism is regular, these meridians are necessarily at right angles to one another. Commonly the meridian of greatest refraction is nearly vertical and the other nearly horizontal; this is called *astigmatism with the rule;* when their relation is reversed, it is called *astigmatism against the rule.* After cataract extraction the meridian of greatest curvature is perpendicular to the corneal incision, and the astigmatism is usually against the rule.

What is a cylindrical lens?

A lens one or both surfaces of which are portions of the surface of a cylinder. While a spherical lens curves equally in all directions, the cylindrical has such a curve in one

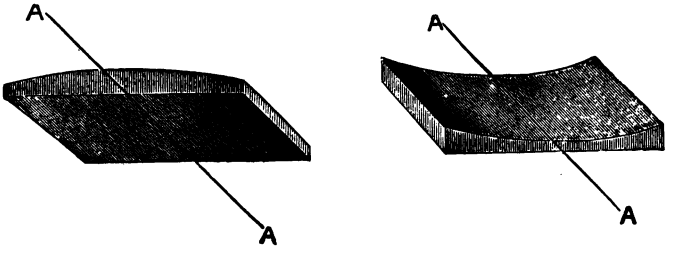

FIG. 13.—Cylindrical lenses.

direction only, and at right angles to this it has no curvature at all. Cylindrical lenses are usually plane on one side; they may be convex or concave; they are numbered, like spherical lenses, according to their form or refracting power, in the direction or meridian of greatest curvature. The direction in which the cylindrical surface has no curvature is called the *axis* of the cylinder or cylindrical lens (see A–A, in Fig. 13). To indicate that a lens is cylindrical, the abbreviation cy. or cyl. is placed after the number indicating its strength; thus, 2 D. cyl.

How does a cylindrical lens focus light?

All along the axis of the lens the two surfaces are exactly parallel, as at the optical center of a spherical lens, so that the rays which pass through the axis are not refracted at all; the rays that pass through other parts of the lens are turned toward the axis, or from the axis, according as the lens is convex or concave, and the focus to which they are gathered, or from which they are made to diverge, is a line parallel to the axis, instead of a single point, as in the spherical lens.

How does an astigmatic cornea refract and focus light?

As with the spherical lens, the ray passing through the optical center is not refracted, while all other rays are turned toward it, but as the curvature varies in different directions,

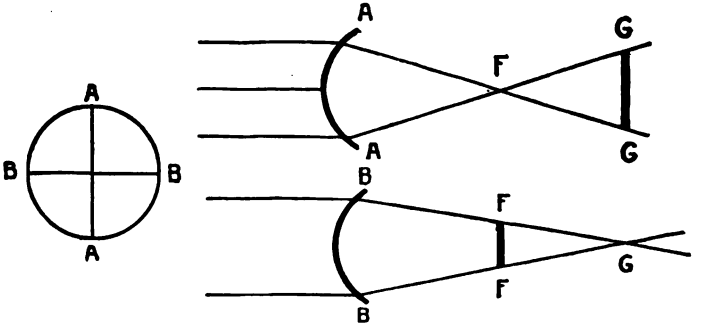

FIG. 14.—How rays are focussed in regular astigmatism.

so the extent to which the rays are turned from their original courses varies, and the rapidity with which they are brought to a focus. In Fig. 14, A–A represents the meridian of greatest curvature, and B–B the meridian of least curvature; in the direction of A–A the rays are turned up and down so much that they are all brought to the level of the central ray at the point F, but in the meridian B–B, at right angles to A–A, they are not turned in from the sides so much, and consequently do not come to a focus until they get back to G; that is, the rays all converge, but unequally until they are focussed in a line F–F; then they begin to diverge up and down, though still converging from the sides, and this con-

tinues until they come to another focus in the line G–G, and then they diverge in all directions; they are most perfectly focussed at one of these two lines, which are called *focal lines.* Nowhere are all the rays brought to a single point.

How does regular astigmatism affect the seeing of lines?

When the astigmatic eye is best adjusted, each point that it looks at makes the impression of a focal line on the retina. When a line is looked at, if it runs in the direction of these focal lines, the focal line of one point overlaps the focal line of the next, and so on, making the impression of a distinct line. But if the direction of the line looked at does not coincide with that of the focal line, the latter, instead of overlapping its neighbor, overlaps what should be the space on either side of the line, and the effect is that the line is seen not as a distinct line, but as a

FIG. 15.—A, Parallel lines as they appear to the normal eye; B, the same lines as seen by an astigmatic eye.

broad, indistinct band; and if there are two such lines close together these impressions run into one another, and they cannot be distinguished, like those in Fig. 15, B.

How is astigmatism corrected?

By placing a convex cylindrical lens before the eye so that its curve will supplement the weaker curve of the cornea, or by placing a concave cylindrical lens so that its curve will partially neutralize the effect of the stronger curve of the cornea. In this way all other rays are caused to turn in equally from all directions toward the central ray, and the focal lines are both brought to a single point. The correction of the astigmatism may leave the eye with some uncorrected hyperopia or myopia, requiring the proper spherical

lens to be combined with the cylindrical, making a *spherocylindrical* lens.

What are the different varieties of astigmatism?

They are shown in Fig. 16, in which C represents the position of an astigmatic cornea, F and G the positions of the two

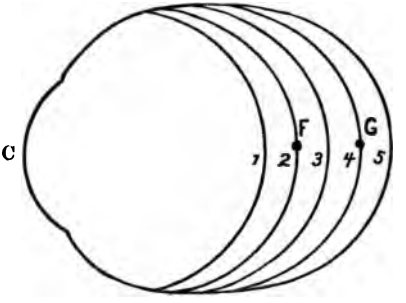

FIG. 16.—Situation of the retina in each variety of astigmatism.

focal lines, and 1, 2, 3, 4, 5, different positions in which the retina may be situated. When the retina is at 1, with both the foci behind it, the error of refraction is called compound hyperopic astigmatism; when the retina is at 2, one focus on the retina and the other behind it, it is called simple hyperopic astigmatism; when the retina, as at 3, lies between the two foci, it is called mixed astigmatism; when the retina is at 4, one focus on it and the other in front of it, it is simple myopic astigmatism; when the retina is at 5, with both of the foci in front of it, the case is one of compound myopic astigmatism.

What are the subjective signs of astigmatism?

Vision both distant and near is imperfect, but the patient may regard it as perfect; and, indeed, very troublesome astigmatism may exist without bringing vision below what is usually called perfect. A point of light appears elongated in certain directions. Lines running in different directions are not seen equally well, but the patient may not appreciate this until he has had the defect pointed out. Much use of the

eyes for either near or distant seeing causes eye-strain. Vision is improved by a cylindrical lens with its axis in the right direction, and made worse by the same lens with its axis turned at right angles to this.

What is the ophthalmometer?

An instrument for measuring the curvature of the cornea by the size of the images reflected from its surface. The essential parts are a telescope, to magnify these images; a test-

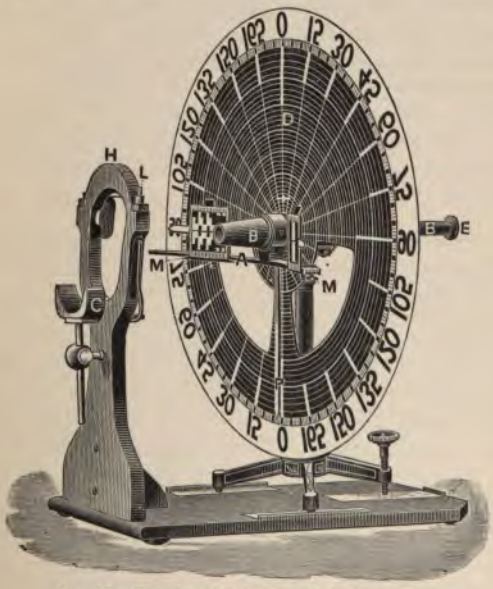

FIG. 17.—The Javal-Schiotz ophthalmometer.

object, the reflected image of which is to be measured; and a doubling prism, which facilitates the measuring. In the Javal and Ried instruments, the two best suited to clinical use, the test-object is made variable. In the former, it is the distance between two mires; in the latter, the diameter of the opening in an iris diaphragm. The size of the test-object

giving a reflected image a certain size indicates, on a graduated scale, the curvature of the cornea from which the image is reflected. By turning the instrument so as to make the measurement in different meridians, the direction of the principal meridians of the cornea and the difference of their curvatures is obtained.

What is the value of the ophthalmometer in measuring refraction?

It indicates accurately the corneal astigmatism. Generally this is a little more than the total astigmatism of the eye, because the lens usually gives rise to a little astigmatism against the rule. By the ophthalmometer, then, we may quickly ascertain the direction of the principal meridians, and in most eyes approximate the amount of the astigmatism. But in a few cases its findings are very misleading, even in regard to the astigmatism. It can give no information as to the presence of hyperopia or myopia.

How is astigmatism recognized by the ophthalmoscope?

The astigmatic cornea interferes with the vision of the surgeon when he looks in through it, in the same way that it interferes with the vision of the patient who looks out through it; it makes the lines running in certain directions indistinct. The lines thus rendered indistinct on looking into the eye are the boundaries of the optic disk or the retinal vessels. The smaller vessels between the disk and the macula are to be taken as the test-object. The strongest convex or weakest concave lens that leaves the vessels clear in a single direction, is the lens required to correct the ametropia in that axis, and the strongest convex or weakest concave that leaves the vessels clear that run at right angles to the first axis, is the one that corrects the ametropia in that direction; the difference between the two is the degree of astigmatism.

How is astigmatism measured by skiascopy?

On account of difference of curvature, the principal meridians have their points of reversal at different distances from the eye. Within both points of reversal the light in the pupil moves with the light on the face in all directions. At the nearer point of reversal the light in the pupil takes the shape

of a band extending in the direction of the principal meridian to which this point of reversal belongs. This band is readily movable with the light on the face in the direction at right angles to it, but exactly at the point of reversal no movement can be secured in its direction. Going beyond this, a reverse movement is seen in the direction of the band, while the movement at right angles to this still remains with that of the light on the face. This continues until the point of reversal for the other principal meridian is reached, where a second band appears, its direction perpendicular to that of the first band, having a reverse movement perpendicular to its own direction, and no movement in the direction of its length. Passing still further back from the eye under examination, the movement of light in the pupil is seen to be inverted in all directions. Measuring the distance from the two points of reversal to the eye gives us the ametropia in the two principal meridians, and the difference between these is the amount of astigmatism.

What should be done for astigmatism?

The cylindrical lenses that correct the astigmatism should be worn all the time. If, on account of presbyopia or very high myopia, different glasses are required for near and distant vision, the same cylindrical should be combined with the different spherical lenses. It is important that the lens should be properly placed before the eye; therefore it is best to have the glasses examined by the surgeon whenever, from dropping out or getting broken, they require to be replaced.

What lenses correct the different varieties of astigmatism?

Simple astigmatism is corrected by a simple cylindrical lens. Mixed and compound astigmatism should be corrected by sphero-cylindrical lenses. Theoretically, either of these latter forms could be corrected by two cylindrical lenses, with their axes at right angles to each other, but such glasses are less likely to be accurately ground, and are more expensive. A preference for two cylindrical lenses, with their axes at an oblique angle, shows that the best sphero-cylindrical lens has not been found. A convex cylinder must always be placed with its axis in the meridian of greatest refraction; a concave

cylinder with its axis in the meridian of least refraction. Either a convex or a concave cylinder can be used to correct the astigmatism in any case, but they will require different sphericals combined with them.

What is irregular astigmatism?

The defect of refraction produced by irregularities of the cornea, such as are left by keratitis, or the irregularities of the lens, that are the first evidence of commencing cataract. It causes imperfect focussing and defective images similar to those caused by poor window-glass. In some degree irregular astigmatism is found in the periphery of the dilated pupil of every eye; it becomes of practical importance as it affects the central part of the pupil, the *visual zone*. While it cannot be corrected by any lens, it is often associated with a certain amount of regular astigmatism, which can be relieved by the use of the proper glass.

What is the aberration of the eye?

The rays that go through the edge of a spherical lens are focussed sooner than those which pass through the lens near its center; this difference in the power of different parts of the lens is called *spherical aberration*. There is a similar condition in most eyes, the refraction at the edge of the pupil being more myopic or less hyperopic than at the center of the pupil; this is called *positive aberration*. When this is reversed, the edge of the pupil being less myopic or more hyperopic than the center, the eye presents *negative aberration*. Aberration may require the use of a lens when the pupil is contracted which differs from the one selected when the pupil was dilated.

What is eye-strain?

The morbid condition resulting from over-use of the muscular or, more commonly, of the nervous apparatus concerned in vision, manifested by irritation or inflammation of the eye or its appendages, especially the retina and choroid, and the conjunctiva and margins of the lids, or by pain in the eye or headache, or by so-called "reflex" disturbances of more distant organs. The headaches of eye-strain may come on only

after special use of the eyes, or may be constant; the majority of all chronic or recurrent headaches are due to this cause, and headaches due in part to other causes are very often aggravated or kept up by eye-strain. The reflex phenomena have been known to include epileptic seizures, chorea, gastric and uterine disturbances, etc. Eye-strain may arise from over-use of eyes free from any serious defect, or in connection with presbyopia or any error of refraction; under the conditions of civilized life it is most commonly due to hyperopia or astigmatism.

What compound lenses are used to correct refraction?

Sphero-cylindrical, spherical on one surface, cylindrical on the other; *sphero-prismatic*, spherical on one or both surfaces, but thicker on one edge than the opposite; *cylindro-prismatic*, cylindrical, on one surface, but thicker at one edge than at the other; *sphero-cylindro-prismatic*, spherical on one surface, cylindrical on the other surface, and thicker at one edge.

What is a decentred lens?

A lens so mounted that the optical center, the thickest part of a convex, or the thinnest part of a concave lens, is not placed before the pupil. Such a lens has the effect of a prismatic compound lens.

What is a toric lens?

A lens one surface of which curves more in one meridian than in the meridian at right angles thereto; somewhat like the surface of an astigmatic cornea. The refraction of such a surface is equivalent to that of a sphero-cylindrical lens.

What are bifocal lenses?

Lenses in which the upper part is adapted to distant vision while the lower part is adapted to near seeing. They are made by taking parts of two lenses and fitting together, one above, the other below, the line separating them being either straight or curved; by using the lens for distance as a basis, and cementing on the lower part of it a small additional lens, called the film or paster; by placing this film or paster between two thin lenses which together constitute the correction for distance, making an "invisible" bifocal; or by grinding two different spherical surfaces upon the one piece of glass.

ESSENTIALS OF DISEASES OF THE EYE.

DISORDERS OF OCULAR MOVEMENTS.

What is the visual axis?

The line joining the *fovea centralis* of the retina with the point from which proceeds the light that is focussed upon the fovea. When the attention is particularly fixed upon one point, the eyes are normally turned so that that particular point can make its impression on the most sensitive part of the retina, the fovea; that is, both the eyes are turned with their visual axes to the point looked at. Such a point is spoken of as the point fixed, or the *fixation-point.*

What is squint or strabismus?

A defect in the movement of the eyes, by which, while one eye directs its visual axis toward the point fixed, the visual axis of the other is directed somewhere else. The first eye is called the *fixing eye,* the second the *deviating eye.*

What is necessary to normal binocular vision?

Both eyes must have their visual axes directed toward the same point; each eye must receive a distinct impression on its retina; these impressions must be transmitted to the cortical centers of vision on the two sides of the brain; and, finally, these separate impressions must be combined so as to give rise to a single idea of the object differing in some respects from either of the impressions from which it is built up. This combination of the two impressions into one is called *binocular fusion.*

What is the mechanism of binocular diplopia?

If one eye is fixed on a certain point and the other turned elsewhere, the image of the point fixed falls on the fovea of the

fixing eye, but upon some other part of the retina of the deviating eye. To the fixing eye the object appears to be in the direction that the eyes are turned, while to the other it appears to be in some other direction. From these two impressions, referred in two different directions, the mind gets the idea of two separate objects some distance apart. The impression made on the fixing eye is called the *true image*, and the impression made on the deviating eye is called the *false image*.

How can you determine which image belongs to the right eye and which to the left?

By placing a piece of red glass before one eye and finding which image is colored by it; or by covering one eye and noting which image disappears; or by placing a prism with its base up or down before one eye and noting which image is correspondingly displaced downward or upward.

What is the relative position of the false image?

The conditions of convergent strabismus are represented in Fig. 18: the eye R fixes on the point O; the eye L deviates

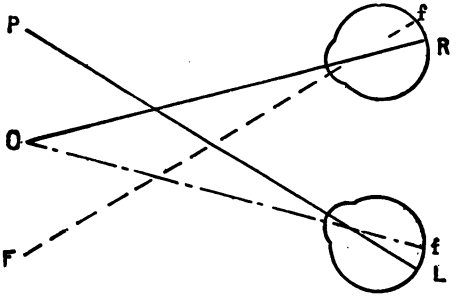

FIG. 18.—Convergent strabismus, homonymous diplopia.

toward some other point (P); in R the image of O is formed just upon the fovea; in L it falls at some other point (f); the false image is therefore referred in the direction f'F to a point F; f and f' being corresponding points in the two retinas—that is, points removed equally and in the same direction from the fovea. In general, *the false image appears*

to be displaced in the direction opposite to that in which the deviating eye is turned. If the eye deviates up, the false image appears below the true, if downward, above; if the deviation is to the right the image is to the left, if to the left the image is to the right; if the eye is rotated one way about its visual axis the image appears to be rotated the other way.

How do you certainly recognize the presence of squint?

Simple inspection will often reveal the defect, but this is not always to be relied on, because, if the center of the cornea be situated a good deal to one side of the visual axis, as we judge the direction of the axis by the position of the cornea, the eyes may be thought to squint when really properly directed, or may really squint when apparently straight. The patient's gaze should therefore be directed toward a certain point and then the fixing eye covered, and immediately the position of the eyes will change so that the other eye can fix on the object, while the originally fixing eye deviates. This test should be repeated until the result is certain, the movement of the eyes when one is covered being satisfactory evidence of the existence of the squint; and the direction of the movement showing in which direction the eye had been deviating.

What are the two principal kinds of squint?

Comitant (or *concomitant*) and *paralytic*. They differ radically in origin, symptoms, course, prognosis, and treatment.

What is comitant squint?

A wrong relation of the visual axes, so that they do not intersect in the point looked at; without marked limitation of the movements of either eye in any particular direction; the squint remains substantially the same whatever direction the eyes may be turned. When the fixing eye is covered, the other promptly fixes and the covered eye deviates, without any change in the position of the head.

What is convergent squint?

The condition in which the visual axes converge too strongly, so that they cross each other nearer to the eyes than the point fixed, as in Fig. 18. It is the most common

form of squint; it gives rise to diplopia in which the image belonging to the right eye is seen to the right, and the image belonging to the left eye to the left; this is called *homonymous diplopia;* it is usually associated with hyperopia, and in some cases is caused by the excessive accommodation rendered necessary in hyperopia of the higher degrees, accommodation and convergence being actions habitually closely associated.

What is divergent squint?

The condition in which the visual axes do not converge enough, either intersecting beyond the point fixed (*relative squint*), or actually diverging (*absolute squint*), so that they do not intersect at all; this is illustrated in Fig. 19. It

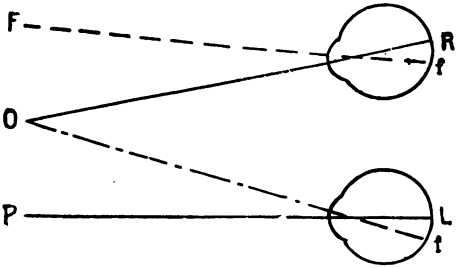

FIG. 19.—Divergent strabismus, crossed diplopia.

causes a diplopia in which the image from the right eye is seen to the left, and the image from the left eye to the right, *crossed diplopia:* it is frequently due to myopia. Highly myopic eyes do not need to use their accommodation, so there is not that stimulus to convergence there is in hyperopic eyes. Then a highly myopic eye, being elongated from before backward, is oval and fits in an oval socket, in which it cannot turn except by changing the shape or direction of that socket by actually pressing aside some of the orbital tissues composing it; so that convergence is actually more difficult for an elongated myopic eye than it is for a spherical eye which turns freely in its spherical socket without changing its shape. Hence, eyes that are highly myopic, unless the M. is corrected, nearly always come to have a divergent squint, either relative or absolute.

What is vertical squint?

That condition in which the visual axes do not lie in the same plane, but one is turned relatively upward or downward, as compared with the other. It gives rise to a diplopia in which one image, that from the eye that is turned down, is higher than the other, called *vertical diplopia*. Usually it is associated with divergent or convergent squint.

What is monolateral or monocular squint?

The condition in which one eye is habitually fixed upon the object, while the other eye habitually deviates. The squint is really not confined to the latter; one is as much at fault as the other, but there is a decided difference in acuteness of vision between the two, and on this account the one that sees the better is habitually used, and the other allowed to deviate. If the eye having the better vision be covered so as to prevent its use, it is promptly caused to deviate, while the worse eye is brought into use and fixes the object. As soon, however, as the better eye is uncovered, it again fixes and the worse one resumes the squint; the squint is practically the same whichever eye exhibits it.

What is alternating squint?

That form in which part of the time it is one eye that squints, and part of the time it is the other that deviates. If at any time the fixing eye be covered, the squint is promptly transferred to it, and it continues to deviate after it is uncovered, until in some way the seeing of the other eye is interrupted. This form occurs when the acuteness of vision is about the same in one eye as the other; a modified form of it is seen when one eye sees better at a distance, and the other has the better near vision.

What is intermittent or periodic squint?

One that is only present a certain part of the time, while at other times the direction and movements of the eyes are quite normal; its periodicity is not usually regular, but is apt to bear some relation to the condition of the general nervous system. Accompanying strong effort at accommodation it is called *accommodative squint;* with convulsions, *convulsive squint;* as a manifestation of hysteria, *hysterical squint.* The

opposite of periodic is *constant squint*, where the visual axes are never brought into normal relations; but in many cases of constant squint, the amount of deviation at different times varies greatly. Care must be taken not to confound paralytic with intermittent squint.

How is amblyopia connected with squint?

Squinting eyes rarely have full normal vision. In very many cases this is due to some evident defect in the eye, as an opacity of the cornea or other refractive medium, or a considerable error of refraction. But in others the cause is not so evident, being probably a lesion or defective development of the optic nerve or the visual centers. In some of these latter cases it is supposed that the squint causes the amblyopia; either by lack of use causing a lack of development; or by an actual suppression of the falsely placed image of the deviating eye, to prevent the annoyance of diplopia. Such impairment of vision is called *amblyopia ex anopsia.* In this case the amblyopia is the effect of the squint. In the former case the amblyopia is a cause of squint. Binocular fusion and the perfectly accurate coördination of the movements required for binocular vision are attained by practice in the use of the eyes during the early years of life. And when for any reason the guidance of these movements by the aid of the impressions received on the retina is interfered with, such perfect coordination may never be secured, and the imperfectly seeing eye will be left in a wrong position, or squinting.

When should the treatment of comitant, convergent squint be commenced?

As soon as it is discovered. The function of binocular fusion is usually fully developed by the age of six years, and is rarely capable of complete development after that age. The great majority of cases of convergent squint start before binocular vision has been fully established, and a perfect cure is impossible unless effected before the age mentioned. The normal ocular movements of infancy are irregular and imperfectly coördinated, but if at two or three years there exists a constant or frequent excessive convergence, it must be regarded as a convergent squint and treated accordingly.

What is the general plan of treatment?

Remove all obstacles to normal direction of the eyes by doing away with excessive accommodation. Correct all errors of refraction. Compel the weaker or unused eye to take its share in vision by excluding the other; train the eyes to work together by appropriate exercises; finally, use operative interference when necessary.

How is atropin to be used for squint?

Some cycloplegic must be employed for the accurate measurement of refraction; then both eyes should be kept under the influence of such a drug for some weeks to exclude the influence of efforts of accommodation. Atropin is the best drug for this purpose, because it is the most lasting and constant in its effect upon the ciliary muscle. It may also be used in the fixing or better eye alone to compel the use of the other. For this purpose it may be employed for several months.

How are glasses to be used?

The error of refraction in each eye must be accurately measured by skiascopy, and the full correction worn constantly. Very little difficulty will be encountered in having the lenses worn by children of even two years of age. If the eyes are kept for a time under atropin, and the error of refraction is accurately corrected by the glasses, the child will appreciate the improvement they make in vision, and quickly accept them as a matter of course.

What are the more important means of orthoptic training?

The use of atropin in the fixing eye cultivates normal fixation in the eye which has deviated. If, however, the latter has quite defective vision, the child may still incline to use the atropinized eye. It will then be necessary to cover this eye; a light pad of cotton may be placed behind its correcting glass or fastened before the eye by adhesive plaster. The *fusion tubes* and *amblyoscope* should be used to develope the power of binocular fusion; by carefully showing the child how he can bring the two images into one, and can keep it single by a slight effort when the positions of the tubes are

changed. With older children the stereoscope with especially adapted pictures for appropriate exercises, and the reading bar, may be employed.

When should we operate for squint?

In children, when the squint is constant, and the above measures, faithfully tried for several weeks or months, have failed to completely remove the squint, and have ceased to effect any notable improvement from month to month. In older persons, when the amount of squint is sufficient to cause noticeable deformity, and is not likely to be influenced by other measures.

What are the indications for tenotomy?

The squint must be constant, and the movement of the squinting eye outward not seriously lessened; the deviation must amount to 12 or 15 centrads (6 to 8 degrees), and the case must conform to the above requirements for operative interference.

What instruments are required for a tenotomy?

A pair of toothed forceps, like Fig. 20, with fine points and rather projecting teeth; a pair of scissors slightly curved on

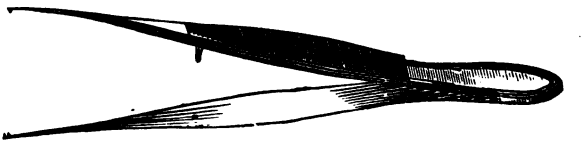

FIG. 20.—Fixation-forceps for seizing firm tissues.

the flat, with fine, but somewhat blunted points, and preferably with spring handles, like those of the author shown in

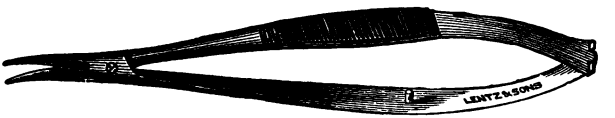

FIG. 21.—Author's strabismus-scissors.

Fig. 21; a strabismus-hook, with the end bent about perpendicular to the shank, this end being less than one millimeter

thick, and about six millimeters long, shown in Fig. 22; and if the operation is done without an assistant, a stop-speculum will be required; a good form is shown in Fig. 23.

How is the operation of tenotomy done?

A local anesthetic having been efficiently applied over the insertion of the tendon to be divided, and the patient's head being supported by the assistant who keeps the eye opened, the conjunctiva is grasped with the forceps in such a way as

FIG. 22.—Tenotomy-hook for raising tendon.

to raise a fold parallel to the corneal margin over the insertion of the tendon, and this fold is divided a little below the middle of the insertion with the scissors, making a cut several

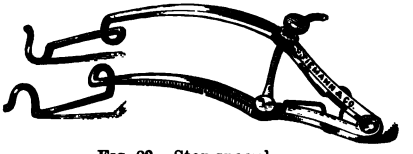

FIG. 23.—Stop-speculum.

millimeters long in the conjunctiva in the direction radiating from the center of the cornea; through this cut the subconjunctival tissue is divided freely in all directions, separating the superficial from the deeper tissues. The forceps are then introduced and made to seize the tendon near the center of its insertion, and raise it from the sclerotic; in doing this the fold of tendon is to correspond to the direction of the tendon, and it is to be cut across at its junction with the sclera; through the opening thus made the hook is to be introduced, and first the upper, then the lower part of the tendon raised on it and divided with the scissors, as close to the insertion as possible. The eye should subsequently be kept closed, and the other eye not used for a day or two.

What are the indications for advancement?

If the deviation to be corrected be comparatively slight—less than 10 or 15 centrads—there is less danger of an over-correction; and less harm will be done, should the operation prove unsuccessful, if advancement is resorted to rather than tenotomy. If there is some decided limitation of the outward movement of the deviating eye, advancement tending to increase the power of the weakened muscle is better than tenotomy, which diminishes the power of the stronger muscle. When the deviation is of such high degree that a single tenotomy will not be sufficient to correct it, tenotomy may be done with advancement at the same time.

How is advancement of the external rectus done?

An incision parallel to the corneal margin is made over the insertion of the tendon or a little in front of it; the tendon is then isolated from adjoining tissue and raised on a strabismus-hook. A very fine curved needle, carrying a silk suture, is introduced about 3 mm. below the upper margin of the tendon, far enough back to effect the desired advancement, and, passing from without inward, is brought out between the upper margin of the tendon and the eyeball. It is then introduced into the sclera close to the corneal margin, the conjunctiva being drawn aside for the purpose; here it is passed, parallel to the corneal margin, deep enough to include sufficient of the sclera to give a perfectly firm hold, but *not to perforate its whole thickness.* Finally, it is introduced beneath the tendon, emerging about 3 mm. above its lower margin and opposite the point of first introduction. The two loops of ligature between its passages through the tendon and the sclera are drawn well out of the way; the tendon is divided at its insertion into the sclera and, if desirable, the end of the tendon cut off; the tightening of the suture then brings forward the tendon into its new position, where it is securely retained. Usually the stitch causes little irritation, and may be allowed to remain a week or more. At first the operated eye is covered with a light dressing and the other eye is used as little as possible, but the eyes should be brought into use together as soon as the swelling and irritation caused by the operation begin to subside.

What operations are done for divergent squint?

Tenotomy may be done on the external rectus muscle, or advancement of the internal rectus, or both together. If the deviation is of high degree it will be necessary thus to operate on both eyes. The tendency is for the effect of an operation for divergent squint to diminish subsequently, hence an over-correction must be aimed at.

What operations may be done for vertical squint?

A tenotomy of the superior rectus of the eye which deviates upward or of the inferior rectus of the eye which is turned more downward; or an advancement of the inferior rectus of the eye which turns up, or of the superior rectus of the eye which turns down. The choice should be made so as to give the easiest movement of the eyes in the direction they are most used.

What is heterophoria, latent, or dynamic squint?

A tendency to turn the visual axes in different directions, which is overcome in order to avoid the diplopia it would cause. This is accomplished by an extra effort on the part of one or more of the muscles that move the eyeball; this extra effort may result in eye-strain. This condition is often spoken of as "insufficiency" of a certain muscle or muscles, but this term is better reserved for those cases of actual paresis of one or more muscles, which cases bear the same relation to paralytic squint that heterophoria does to comitant squint.

How is heterophoria detected and measured?

On covering the eye, and so preventing binocular diplopia, the extra effort to keep the eyes straight is relaxed, and the covered eye is allowed to deviate in the direction in which it tends. But upon uncovering, it quickly resumes its original forced position. This recovery is usually more rapid, and therefore more noticeable than the deviation; its extent indicates the degree or amount of heterophoria present. Again, by placing a prism of sufficient strength before one eye, diplopia is rendered inevitable, and any extra effort is relaxed. If, now, there be no tendency to deviation, the false image will appear just where the prism used would throw it; but if there be heterophoria the eye behind the prism will deviate,

and the image seen by it will have a corresponding false position. The strength of the prism required to bring the false image to the position it would take in *orthophoria* (tending of the visual axes toward the same point) is the measure of the degree of heterophoria.

What is the Maddox-rod test?

A piece of glass rod (or several pieces, placed side by side), or a piece of glass, with one or more grooves in it (see Fig. 24), is placed before one eye, and both eyes are directed

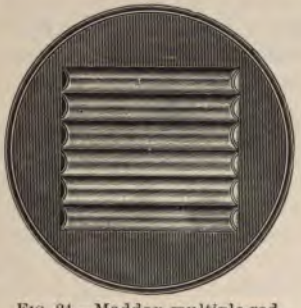

FIG. 24.—Maddox multiple-rod.

toward a point of light twenty feet or more distant. The eye which looks through the rod sees the point of light as a narrow line, while to the other eye it has its usual appearance. If both eyes are properly directed toward the point, the line seen through the rod seems to pass through the light as seen by the other eye, but if heterophoria be present, the line appears to be displaced in the direction opposite to that in which the eye behind the rod tends to deviate.

What is the blue-glass test?

In most cases of heterophoria, by simply covering one eye with a piece of dark blue or cobalt glass, the two images of a point of light which the two eyes receive will be rendered so different that they will no longer be fused; then, if there be any tendency to heterophoria, double images will be seen. Both this and the rod test may also be applied to cases of actual squint. These tests will be most successful if care be

taken to place the rod or the blue glass in front of the eye which has the better vision.

What are the varieties of heterophoria?

Exophoria, a tendency toward divergence—latent divergent squint—in which the diplopia is of the crossed variety; *esophoria*, a tendency to excess of convergence—latent convergent squint—in which the diplopia is homonymous; *hyperphoria*, a tendency of one visual axis to turn above the other—latent vertical squint; *right hyperphoria* is the turning of the right visual axis above the left, the image belonging to the right eye appearing to be the lower; *left hyperphoria* is the turning of the left eye upward, the image belonging to it appearing below.

What are the symptoms of heterophoria?

Aching of the head and eyes, especially after near work; a sense of strain or mental confusion or vertigo may arise after use of the eyes; congestion or inflammation of the eye and its appendages may occur. Sometimes diplopia and manifest squint arise when the patient is particularly tired or is weakened by disease.

What is the treatment for heterophoria?

Where it is temporary or its degree is quite variable, measures calculated to improve the general condition of the nervous system are mainly to be relied on, with regulation of the work required of the eyes, and the performance of special exercises for the eye muscles. When the faulty tendency is found to remain constant for a considerable time, prisms should be worn of such strength and turned in such direction that the eyes will be allowed to deviate in the direction they tend, and the strain of keeping them straight avoided. If such a tendency is found to amount to over 10 centrads and to persist for a considerable time an attempt may be made to correct it, as in manifest squint, by tenotomy of the muscle toward which the eye tends to turn, or advancement of its antagonist, without tenotomy.

What is paralytic squint?

The deviation which occurs when the attempt is made to

turn the eyes in a certain direction by means of a muscle or muscles partly or wholly paralyzed; when this attempt is made the eye with sound muscles turns normally, but the eye with the paralyzed muscle lags behind, beginning to deviate as the eyes are turned, so that this muscle is required to perform its function, and deviating more as a greater effort is required. The degree of squint and of the separation of the double images it causes varies with the direction the eyes are turned, there being none at all in certain directions.

How do you ascertain the presence of paralytic squint?

By having the patient turn his eyes successively in various directions and noting the eye that deviates and what particular movements it fails to properly execute; also, by having the patient notice the kind and extent of his diplopia, and that it varies on looking in different directions. The Maddox-rod and the blue-glass tests are very useful, because they clearly demonstrate which image belongs to the right and which to the left eye.

How do you find which muscle is at fault?

This may be discovered by the evident lagging of one eye when required to look in a certain direction, or the patient, being made to follow with his eyes the movement of a candle-flame in different directions, notes in which direction the images become most widely separated. The image that appears farthest in this direction belongs to the eye which lags in this particular movement—the eye to which is attached the paralyzed or weakened muscle. Which eye this is may be ascertained by covering first one and then the other, and noting which causes the image to disappear, or, better, by covering one eye with red glass and finding which image is made red. Knowing the eye affected and the direction in which its movement is impaired, we know from the function of the different muscles which must be at fault. When two muscles have somewhat the same function, the test must be repeated and slightly varied to locate exactly the defect. For instance, if double vision occurs on looking down, we know that the weakness is in one of the muscles that turn the eyes downward; if, when the eyes are turned strongly

down, it is found that the lower image belongs to the right eye, we know that the right eye is lagging, and that either the inferior rectus or the superior oblique of that eye is at fault. We then try repeatedly to determine whether the images are more widely separated when the candle is held downward and to the right, in the direction that the eye would be turned chiefly by the inferior rectus; or whether they are more widely separated when the candle is held downward and to the left, in the direction the eye should be turned by the superior oblique. By careful tests of this kind the paralysis or even the slight weakening of a single muscle is readily recognized; but when two or more muscles are affected, and particularly when some time has elapsed and compensatory actions of the other muscles have been established, it is often extremely difficult to gain a clear idea of the exact conditions present.

What are the causes of paralytic squint?

Direct injury to the muscle concerned, lesion of the centers governing its action, or lesion to the trunk of the nerve supplying the muscle, palsies of the last kind being by far the most frequent. The most common cause of such lesions is tertiary syphilis; and after it local neuritis due to the rheumatic diathesis, "cold," or local injury, as from blows on the head.

How are cases of paralytic squint classified?

They may be grouped according to the location of the lesion as nuclear, trunkal, or muscular, but usually in practise it is convenient to classify cases according to the nerve-supply of the affected muscle or muscles.

What are the manifestations of oculomotor paralysis?

Ptosis, or falling of and inability to raise the upper lid, due to paralysis of the elevator of the lid; inability to move the eye, except outward and downward, from its central position, due to paralysis of the internal, superior, and inferior recti; this causes a divergent or vertical squint on endeavoring to converge the eyes or to look toward the side of the sound eye, or upward or downward. The squint is attended with crossed

or vertical diplopia; the inferior oblique muscle also suffers; if the case is of long standing, the eye is permanently turned down and out. Sometimes only one or a part of the muscles are involved.

What is ophthalmoplegia interna?

Paralysis of the ciliary muscle and sphincter of the iris, causing loss of the power of accommodation and partial dilatation of the pupil, without involvement of any of the extra-ocular muscles supplied by the oculomotor nerve. It is always due to a lesion of the nuclei governing accommodation and contraction of the pupil.

What is recurrent oculomotor paralysis?

A form in which attacks begin in early life, marked by extreme headaches, usually confined to one side of the head, with nausea and vomiting, paralysis of the oculomotor nerve, and swelling about the orbit on the affected side. After a few days the attack subsides and the affected muscles gradually regain their power, but similar attacks follow, the affected muscles become permanently weakened and, finally, completely paralyzed. Autointoxication may cause it.

What are the effects of abducens or sixth-nerve paralysis?

Convergent squint and homonymous diplopia on looking toward the side of the affected muscle, due to loss of power in the external rectus muscle, to which this nerve is distributed. This is the commonest form of paralytic squint.

What are the symptoms of paralysis of the patheticus or fourth cranial nerve?

Loss of power in the superior oblique muscle, causing imperfect movement of the eye down and out; and on attempting to look in that direction homonymous diplopia, but with the false image lower than the true, and with its top inclined toward the true one.

What is ophthalmoplegia externa?

The simultaneous paralysis of all the muscles that act on the exterior of the eyeball.

How would you treat paralytic squint?

Remove any obvious removable cause, secure as favorable conditions of nutrition as possible, and in recent cases give potassium iodid in increasing doses until decided improvement occurs, or the limit of physiologic tolerance is reached. At a later stage give strychnin in the same way. Locally, stretching of the muscle may be resorted to by seizing the insertion of the muscle (after the instillation of cocain) and dragging it slowly back and forth for one or two minutes. In the early stages operative treatment is of no benefit, but later, with partial recovery of the affected muscles and efforts at compensation on the part of other muscles, conditions often arise clearly resembling those of comitant squint, in which carefully planned operative interference or the aid of appropriate prisms may be of great benefit.

What is nystagmus?

A disorder of the motility of the eyes, in which the eyeball oscillates rapidly from side to side or vertically, or with a rotary movement. It is nearly always associated with imperfect vision, often it is congenital, and although not directly amenable to treatment, is improved by attention to general or local hygiene, or the removal of sources of strain, and by improvement of vision, as by glasses. In cases of long-standing blindness or great impairment of vision, it is very often present; it may arise only when an attempt is made to fix the eyes for accurate vision. A form called *miners' nystagmus* is seen among miners, who work by poor light and with their eyes turned strongly upward. For nystagmus caused by blindness there is no remedy; for miners' nystagmus, change of occupation or, at least, working in a different position and with better light is essential.

THE FIELD OF VISION AND COLOR-PERCEPTION.

What is the field of vision?

The space before the eye in any part of which an object of sufficient size can be seen; when not otherwise indicated, it is to be taken as the space in which objects can be seen by one eye without any change in the direction of its visual axis.

The *binocular field* is the whole space in which they can be seen by either eye, or both, by turning the eyes, but without changing the position of the head; the *field of fixation* is that part of the field of vision in which objects can be directly looked at—that part toward which the visual axis can be turned; the *field of binocular fixation*, or of true binocular vision, is the part in which both eyes may be made to fix the object at the same time.

How can you ascertain the field of vision?

Cover effectually the eye not to be tested, then face the patient and close your eye that is opposite his covered one; in testing the left eye keep open your right eye, and *vice versâ*. If they are both normal your field of vision will now correspond with the patient's for any object that is equidistant from both. Hold the hand in different directions, and find if the patient can tell whether the fingers are kept still or moved, as far in every direction as you can perceive them, making due allowance if his brow or nose be more or less prominent than your own. During the test the patient's eye must be steadily fixed on yours, while your own is as constantly directed toward his.

What is a perimeter?

An instrument with a graduated arc that can be revolved so as to describe the surface of a hemisphere, along which arc the test-object can be moved (see Fig. 25). The visual axis of the eye to be tested is made to coincide with the axis about which the arc turns, and the portion of the hemisphere in which objects can be seen is noted. The object, which is commonly a square 10 mm. on a side, of white upon a black ground, is moved along the arc until it is just seen by the eye which is fixed on the axis of the arc. Connecting the points where the test-object is just seen by a line, an exact outline of the field of vision is obtained.

What does impairment of the field of vision indicate?

A dense clot in front of some part of the retina, or detachment, or serious disease of a portion of the retina; or a lesion of the optic nerve, chiasm, optic tract, or visual centers. The

general location of the lesion is commonly indicated by the form of limitation of the field, and its exact location may often be determined by accompanying symptoms.

How may the field of vision be affected by disease?

It may be contracted, either *concentrically*—that is, evenly in all directions—or *irregularly;* or it may present *scotomata*,

FIG. 25.—Perimeter.

patches in which there is partial or complete blindness, surrounded by parts where vision is partly or entirely retained.

What is concentric contraction of the field?

A comparatively equal narrowing of the field in all directions, the general form remaining approximately the same as that of the normal field (see Fig. 26). It is significant of primary atrophy of the optic nerve and poisoning by certain drugs, especially quinin. The apparent amount of concentric

contraction will depend on the size of the test-object used, but if not otherwise stated it may be assumed that the object has been one centimeter square.

What is irregular contraction of the field?

Any form in which the outer limits of the field are narrowed and their shape essentially changed, as in the outline of the white area of Fig. 27. Such a field is seen

FIG. 26.—Concentric contraction of the field of vision. The cross indicates the fixation-point; the shaded area, the part of the normal field which has been lost.

FIG. 27.—Irregular contraction of the field of vision. The part of the normal field that has been destroyed is shown by the shaded area.

in atrophy of the optic nerve following neuritis, and in glaucoma.

What is amblyopia?

Impairment of vision in a part or whole of the field, without any perceptible lesion or anomaly of the eye to account for it.

What is amaurosis?

Complete loss of sight, without perceptible lesion of the eye to account for it.

What is hemianopsia?

A form of irregular contraction in which one-half of the visual field is obliterated. When objects cannot be seen to the temporal side of the field of vision, it is called *temporal hemianopsia;* to the nasal side, *nasal hemianopsia;* when the temporal or the nasal half is lost from the fields of both eyes,

it is called *bitemporal* or *binasal hemianopsia;* when the right or the left half of the field is affected in both eyes, it is called *homonymous hemianopsia.*

What are the outlines of the field in homonymous hemianopsia?

The side of the field not affected has the usual normal limit, but it is separated from the blind "half" of the field by a line approximately vertical, except near the fixation-point. In most cases this boundary between the blind and seeing portions of the field, near the center, bends toward the blind part, going around the fixation-point in such a way as to leave it in the seeing part of the field; this is illustrated in Fig. 28. In homonymous hemianopsia the fields of the

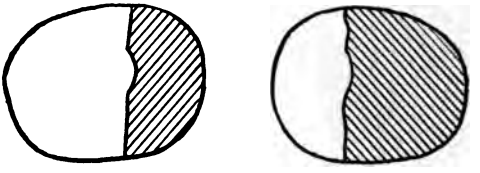

FIG. 28.—Field of vision in right homonymous hemianopsia, from apoplectic lesion involving left occipital lobe.

two eyes are not equally affected, because the temporal is much larger than the nasal "half." For instance, in right homonymous hemianopsia, the temporal portion of the field for the right eye and the nasal portion of the field for the left being lost, the field for the right eye will be much smaller than that for the left. On this account such a condition is sometimes mistaken for blindness of the right eye.

What is the significance of homonymous hemianopsia?

It indicates a lesion of the visual centers or of the optic tract, on the side opposite the blind field, somewhere back of the optic chiasm, and is, therefore, of great importance in locating cerebral disease (see Eye-symptoms of General Disease).

What are homonymous sector defects of the field?

Blindness of similar parts of the two fields. Usually the

blind portion is included between lines radiating from the fixation-point, as in a quadrant defect, where corresponding quarters of each field are lost. Such defects have the same significance as homonymous hemianopsia, except that only a part of the tract or centers is involved. The defect stops short of the center of the field of vision, as in hemianopsia.

What significance attaches to other forms of hemianopsia?

Bitemporal hemianopsia can be produced by a single lesion only when this involves the optic chiasm itself; where the fibers cross which are distributed to the nasal portions of the two retinas, and on the integrity of which the temporal fields depend. *Binasal hemianopsia* can scarcely be produced by a single lesion; it indicates symmetrical lesions of the two optic tracts. Loss of the upper or lower half of the field in one eye usually depends on an ocular lesion, like detachment of the retina. When it affects both eyes it is commonly hysterical, but it may result from a lesion involving corresponding parts of the visual cortex in both the occipital lobes.

What can cause blindness of one eye without affecting the other?

Only a lesion in front of the optic chiasm involving the nerve or the eyeball itself. A part of the field of one eye may be lost by a lesion just at the chiasm, but limited to the fibers going to that eye. This occurs sometimes in akromegaly.

What is color-blindness?

Inability to receive from certain colors the impression that they usually make on the normal eye. The colors that most notably fail to make the proper impression are red and its complementary color, green; these do not usually appear as black, but are not distinguishable from each other, or from certain grays and browns. The defect may be partial, so that only certain delicate shades are confused; or total, the brightest red being indistinguishable from the brightest green. Even partial color-blindness is very dangerous in one who has to distinguish red and green signals. For tests of color-perception, see Tests for Railroad Service.

How large is the normal field of vision for various colors?

It varies for the different colors. The relative sizes for some of them are shown in Fig. 29; they are all smaller than the field for white; the field for yellow is usually smaller than the field for blue. The size of the field for any color varies

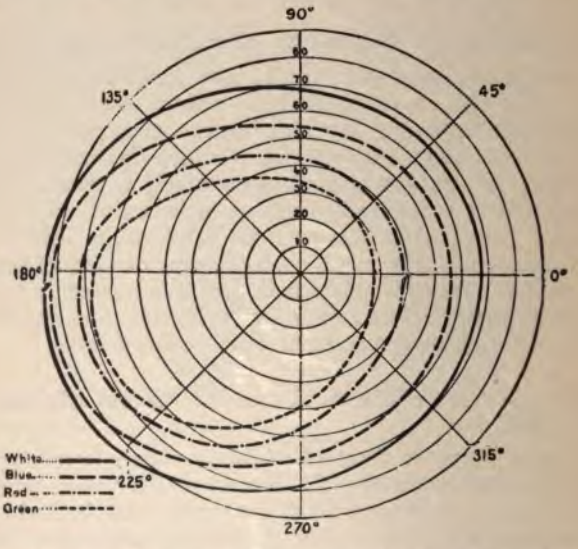

FIG. 29.—Chart of the normal fields of vision for white and colors, taken with test-objects one centimeter square (after Landolt).

considerably in different persons, and for the same person with different degrees of illumination, as well as with the size of the test-object.

How is color-perception affected by disease?

There may be concentric narrowing of the fields, which may be extreme or go on to the complete obliteration of the field for one or more colors, as in optic atrophy. Or there may be a *scotoma*, usually including the point of fixation and neighboring regions, while the outer margins of the field of vision remain normal. Sometimes, while the full field is re-

tained for form, one-half of it becomes color-blind—*hemiachromatopsia.* In general, lesions affecting the optic nerve tracts or centers disturb color vision before they prevent the recognition of form, so that the mapping of the fields for colors may give the earliest indication of optic atrophy.

How can you test the field of vision for the different colors?

In the same way as the field for white or for form, except that a colored object, as one of the Holmgren wools, is to be used. It is well to hold several of these in the hand, and expose one at such a distance from the center of the field that it cannot be recognized; move it gradually toward the center of the field until the patient is able to name the color with certainty, while still keeping his eye directed toward the original point of fixation. With the perimeter, a colored test-object (usually 1 cm. square) is substituted for the white square used for taking the field for form; still better is a disk with which either of the various colors may be exposed.

What is chromatopsia?

The condition in which all objects appear more or less tinged with a certain color, as blue or red. The blue coloration occurs most frequently in old people after cataract extraction; red is noticed with snow-blindness. Usually objects recover their normal appearance after some days or weeks. A yellow color is sometimes noticed by patients suffering from jaundice, from snake-bite, or from santonin-poisoning.

OBJECTIVE EXAMINATIONS OF THE EYE.

How would you make a simple inspection of the eye?

Place the patient in the best accessible light, not exactly facing it, but still well exposed to it, and before touching the eye or lids, notice the color and form of the lids, the width to which they are separated, the appearances and position of the lashes, any evidences of discharge, and the redness of the portion of the eyeball exposed to view; the patient may be directed to look up to secure a wider opening of the lids, or to look in various directions to expose different parts of the globe. The lids are then to be gently separated by pressing the ball of the thumb on one and the forefinger on the other.

If done gently, so as not to provoke resistance, very little force is required if both the lids and the hand are perfectly dry; the pressure should be made over the brow and lower margin of the orbit, not on the part of the lid resting on the eyeball. With the lids thus separated, the position and appearances of the lacrimal puncta are to be noted, and the eyeball more fully inspected.

How do you evert the eyelids?

The lower, by simply pulling down the skin of the lid and getting the patient to look up. For the upper, have the patient look down so as to relax the elevator of the lid, then seize the free margin of the lid between the thumb and finger of one hand, drawing the lid downward and a little from the eyeball, until it is slightly on the stretch; then place the end of a probe, lead pencil, or similar object upon the lid at the point where it is designed to fold it over; this must be at the upper margin of the cartilage, about half an inch from the border of the lid; with the probe or pencil make enough downward pressure to keep the upper part of the lid on the stretch, when the drawing of the thumb and finger is relaxed. With the upper margin of the tarsal cartilage thus fixed, the free border of the lid is to be raised, and the lid thus folded upon itself; the probe may then be withdrawn, and simply keeping the free margin of the lid pressed against the part on which it is folded will keep the lid from turning in again. Care must be taken to have the lid pulled well down, and to apply the probe point far enough up from the lid margin, and not to let the whole lid slip up when the attempt is made to raise the free margin. When an infant cries and strongly closes the lids, to evert them it is only necessary to have lids and fingers thoroughly dry, so that they will stick, and pressing the thumb and finger on the respective lids at their free margin, separate them. When the margins of the lids are thus separated, the violent contraction of the orbicularis presses in the orbital margin of the cartilage, in place of the probe that would otherwise be needed upon the lid.

What should be noted as to the everted lids?

Their redness, the degree of swelling, and opacity of the

conjunctival and subconjunctival tissue. Normally these tissues are transparent and we readily see through them the vessels and the yellowish stripes perpendicular to the lid margin that mark the position of Meibomian glands. Swelling may be a general thickening or may cause unevenness of the surface, as *granulations* of various sorts. Opacity may be due to changes in the epithelium or to exudate in deeper tissues. Cicatrices, tumors, and changes in color that mark the seat of a chalazion or tarsal cyst are also to be noted.

How is a view obtained of the upper cul-de-sac of the conjunctiva?

So-called eversion is only a folding of the upper lid on itself and does not reveal the whole of its under surface. To do this, have the eye turned down as strongly as possible; then draw the lid away from the globe as much as possible, and throw the light into the space so exposed (here the ophthalmoscope mirror may be useful), and look in the direction of the narrow space thus obtained. To raise the lid from the globe, and also to keep the eye open during operations, and sometimes to get a view of the cornea in children, the lid

FIG. 30.—Lid elevator.

elevator or lid retractor, such as is shown in Fig. 30, is very useful.

What is the catoptric examination of the cornea?

The inspection of reflections formed by the surface of the cornea. It may be made by placing the patient facing a window; and, while he rolls the eye in various directions, watching the image of the window formed by reflection from the corneal surface. Any irregularity due, for instance, to a foreign body or a corneal ulcer or cicatrix will cause a break or distortion of the margin of the image of the window as it passes over it. In place of the window a white card, strongly illuminated, may be held before the eye and its reflection studied, or, better still, for the detection of irregularities due

to previous inflammation, we may in the same way use a card marked with alternate rings of black and white, called a Placido disk, and shown in Fig. 31. The ophthalmometer

FIG. 31.—Modified Placido's disk.

(see p. 43) is really an instrument for studying the catoptric images of the cornea, and may be used with advantage even when the corneal astigmatism is irregular.

What is the catoptric examination of the crystalline lens?

The study of the reflection from its posterior surface. The pupil should be somewhat dilated; the examination is made in a dark room; the patient is to face the surgeon and a candle- or lamp-flame, and to look halfway between the flame and the surgeon's face; the surgeon sees a bright image of the flame reflected from the patient's cornea, and within the pupil a second very much fainter image, which is formed by the reflection from the posterior surface of the lens. When the lamp-flame is moved about the corneal image is seen to move in the same direction, but the lens image moves in just the opposite direction; when the lens image can thus be seen

it proves that the lens is present in its proper position and transparent.

How do you examine the eye by oblique illumination?

Place the patient so that the source of light, preferably a bright lamp-flame in a darkened room, shall be on the side of the eye to be examined and but a very little in front. The observer places himself directly in front of the patient, and concentrates the light on the anterior part of the eye with a strong convex lens (see Fig. 32). From time to time the eye

FIG. 32.—Examination of the eye by oblique illumination (De Schweinitz).

may be turned in different directions, so that the light will strike it at various angles.

What is to be especially looked for by this method of examination?

Foreign bodies, opacities of the cornea such as are due to cicatrices, exudate, pus, blood-vessels, etc.; blood, pus, lymph, cholesterin, or foreign bodies in the anterior chamber; and specks of opacity on the capsule of the lens, or in the substance of the lens itself, or even in the anterior portion of

the vitreous chamber. The appearance of the iris is also to be thus studied.

What is the corneal loupe?

A strong convex lens used as a magnifier in examining the eye by oblique illumination. To get its full benefit it must be held at a little less than its focal distance from the part it is desired to examine. This part must be strongly illuminated because the enlargement of the image lessens its brilliancy.

What is the binocular magnifier?

A combination of a convex lens and prism for each eye, so as to extend the range of binocular vision for small objects; one form of it is shown in Fig. 33. The two lenses are joined

FIG. 33.—Jackson's binocular magnifying lens. The broken lines show the directions of the two lines of sight meeting in the point looked at.

together at an angle, so that each will be perpendicular to the visual axis of the eye that looks through it. The binocular magnifier is of especial value in determining the relative depth of different points, as opacities in the cornea or crystalline lens, and in the removal of foreign bodies and misplaced lashes. (See also page 202.)

How do you test the tension of the eyeball?

Let the eye be turned down and the lid allowed to close passively, that is, without any spasm of the orbicularis; place the tips of the two forefingers on the lid just under the brow, and press alternately with first one and then the other, and judge how much pressure you have to exert in order to dent the eyeball. The lid is allowed to fall in order that the fingers may be applied above the cartilage, through the

thinner, more flexible portion of the lid. Another way is to have the patient look up, and then make the test on the lower part of the exposed sclerotic or through the lower lid. Where one eye is normal apply the test alternately to the sound and to the suspected eye, or, if both eyes are suspected, use your own eyes as a standard for comparison, remembering that the sensation produced varies with the thickness of the lids and the rigidity of the sclerotic in different persons. Certainty and confidence in this maneuver are only to be attained by much practise with it.

How is the state of tension of the eyeball recorded?

By the letter T., to which is prefixed the sign + when the tension is increased above the normal; and the sign — when the tension is below the normal. It is also customary to indicate the degree of departure from the normal by the numbers 1, 2, or 3, but these are not to be taken as having any definite value. Thus: +T.1 is simply a short way of indicating that the tension is certainly increased, but not very much; +T.2 means tension increased a good deal, but not so high as it is sometimes found to be; and +T.3, that the eyeball is of great or "stony" hardness.

How are specimens of conjunctival discharge taken for examination?

A loop of platinum wire is sterilized in an alcohol flame, and with it a minute portion of the conjunctival discharge is taken up and transferred to a perfectly clean cover-glass; another cover-glass is pressed firmly over this, and the two rubbed together to diffuse the film of discharge evenly over their surfaces; each cover-glass is then placed in a spring-clip, which will hold it so as to prevent any mistake as to which side the film is on while it is being stained, washed, and prepared for mounting.

How are such specimens prepared?

A few drops of the staining fluid are placed upon the film for the required number of minutes; then the specimen is thoroughly washed and placed upon a drop of distilled water on a glass slide. It is now ready for examination; if worth preserving permanently, it may be removed from the slide,

thoroughly dried, and mounted in balsam. The most generally useful staining fluid is a mixture of 30 parts of strong alcoholic solution of methylene-blue with 100 parts of a 1 per cent. solution of caustic potash. For diphtheria, a modified Löffler solution; for the gonococcus, the Gram method may be employed,

What more does the complete bacteriologic examination include?

The making of cultures from inoculations with the conjunctival discharge, and the careful study of these cultures, both with the naked eye and with the microscope, and their inoculation upon other media or animals; the culture-media must be varied to suit particular germs; there is no one medium which will give reliable results regarding all the pathogenic bacteria that occur on the conjunctiva.

DISEASES OF THE LIDS.

What is marginal blepharitis?

A chronic inflammation of the skin of the lid margin, usually associated with conjunctivitis, and often leading to changes in all the tissues of the lid. There are two forms: a squamous, in which the lid margin is reddened and covered with fine scales; and an ulcerous or pustular form, in which the lashes are matted together with scabs, under which are ulcerations. The inflammation involving the roots of the lashes, these become deformed, drop out, and if the disease continues are finally destroyed altogether. The lid often becomes considerably thickened and its margin rounded, and the few remaining lashes are displaced. Both eyes are usually affected.

What is the treatment for marginal blepharitis?

Remove eye-strain or any general vice of nutrition that may help cause it. Carefully and persistently treat the conjunctivitis, especially by applications to the inner surface of the lids. When scabs or crusts are present, have them removed after thorough soaking in warm water at least once daily. When this leaves an open ulcer touch it with trikresol, carbolic acid or a solution of silver nitrate. The ointment of the yellow

oxid of mercury should be applied to the margin and inner surface of the lid after the removal of the crusts, and gently but thoroughly rubbed in daily.

What is hordeolum or stye?

A circumscribed purulent inflammation occurring in the eyelids near their margin, and usually centering about a hair-follicle; it may be attended with local swelling of the conjunctiva, and when near the outer canthus may cause great swelling of both lids. The affection usually runs its course in a few days, but a succession of styes is apt to occur, and sometimes several appear at the same time.

How is stye to be treated?

At a very early stage its contents may be pressed out through a gland opening. Later, the closed lids may be bathed three or four times a day with very hot water, and borax and boric-acid solution instilled if there is smarting of the conjunctiva. When suppuration has occurred, the stye may be opened, though this is often unnecessary; if, after once opening, the stye inclines to scab over and become chronic, the scab should be removed, the cavity emptied, and its interior touched with the point of a crystal of copper sulphate. To prevent a succession of styes, eye-strain should be carefully sought for and corrected, and internally a saline laxative or potassium bitartrate should be given. The tincture of the chlorid of iron or some similar preparation, with small doses of quinin, may also be required.

What other inflammations involve the lids?

Those caused by poison oak and poison ivy sometimes cause complete closure of the lids and much suffering. *Atropin* in a few susceptible persons causes redness and swelling of the lids; and other *drug eruptions* are especially likely to affect the lids. *Herpes zoster* affecting this region may cause swelling; it is very often mistaken for erysipelas, but its course is characteristic, and the pitted scars remain to demonstrate the error of diagnosis as long as the patient lives. *Erysipelas* of this region is especially dangerous, and calls for early and free incision. Inflammation of the tarsal cartilages, *tarsitis*, may arise from inherited syphilis.

What is chalazion?

A small tumor of the lids due to granulation tissue and retained secretion in a Meibomian gland; it causes an elevation of the skin of the lid, beneath which may be felt a lump of firm consistence closely connected with the cartilage; on the inner surface of the lid there is no projection, but a spot of grayish discoloration, marking the point at which the cartilage has been absorbed, allowing the tumor to extend outward. These tumors tend to persist indefinitely if not removed; they are often multiple.

How would you treat a chalazion?

Evert the lid, and after the application of cocain, make a free incision through the discolored spot; press out the contents of the cyst and scrape its walls with a corneal spud or similar instrument. Re-accumulation of the cyst contents will be more certainly prevented if in addition the interior of the sac is touched with the crystal of copper sulphate. Often the cavity is left full of blood, so that the patient must be warned that the tumor will only gradually disappear.

What other peculiar growths are there on the lids?

Sometimes a tumor very similar to a chalazion will develop in connection with the skin of the lid, but it is freely movable over the cartilage and causes no discoloration of the inner surface of the lid; it should be opened through the skin by an incision parallel to the lid margin. *Milium* is the name given those white tumors the size of a pin-head that occur in the skin of the face from retention of the secretion of the sebaceous glands; *molluscum* is the term applied to an inflamed umbilicated tumor the size of a split pea, apparently contagious, and requiring excision; *syphilis*, *rodent ulcer*, *lupus*, *epithelioma*, *sarcoma*, and *nevus* of the lid occur. Clear *cysts* sometimes occur along the lid margin, and may become quite large; they are not connected with the lacrimal apparatus, but arise from the modified sweat-glands of this region; they disappear on puncture and removal of part of the cyst wall.

What is xanthelasma?

A fatty degeneration and infiltration of small areas of skin,

in consequence of which the surface of the part affected is slightly elevated, smooth, and of a yellowish appearance, often compared to wash-leather; it is apt to appear on the lids in elderly persons, and to be symmetrical in its distribution on the lids of the two eyes; it is not indefinitely progressive, and requires no treatment.

What is blepharospasm?

A tonic contraction or cramp of the orbicularis muscle, preventing for the time the voluntary separation of the lids, usually coming on suddenly, and lasting from a few seconds to days or weeks; sometimes it seems to be the reflex of some peripheral irritation, usually of a branch of the trifacial nerve, and in other cases its cause is quite obscure; in some cases it is a manifestation of hysteria.

Its treatment should first be directed to the causes; all eye-strain should be prevented by correcting lenses, etc. Should other measures fail, stretching, or division of the branches of the facial nerve going to this muscle, may be resorted to. Such blepharospasm must not be confounded with a frequent *twitching of the lids*, which is quite common, and which is to many people quite annoying; this twitching may be dependent on local irritation or on eye-strain, but is often more intimately connected with exhaustion or depression of the general nervous system.

What is ptosis?

Inability to raise the upper lid. It is due to deficiency of the muscle itself, paralysis of the branch of the oculomotor nerve supplying it, or the presence of an accumulation of fat or some new growth in the lid itself. In the latter case it may be treated by the removal of the mass that prevents the movement of the lid; and when due to paralysis of either muscular or nervous origin, it is in some cases worth while to bring the lid under the control of the frontalis muscle by connecting the center of the lid with the brow by a subcutaneous cicatrix secured by the use of a suture, or by taking a slip from the tendon of the superior rectus and attaching it to the tarsus of the upper lid.

What is lagophthalmos?

Inability to close the eye completely. It may be due

paralysis of the part of the facial nerve supplying the orbicularis, this part of the nerve in palsies of central origin being sometimes paralyzed when other parts escape, and sometimes escaping when other parts are paralyzed. Or it may be due to cicatrices involving the lids, or to bulging or forward displacement of the eyeball. In such cases it may be best to narrow the palpebral fissure by removing the skin from the edge of both lids near the outer canthus, and stitching them together; this operation is called tarsorraphy.

What is blepharophimosis?

The condition of undue narrowing of the palpebral fissure. It is a deformity that rarely requires treatment unless the eye becomes the seat of a chronic conjunctivitis, in which case it aggravates the disease and constitutes a serious obstacle to the proper eversion and treatment of the lids; it is to be remedied by the operation of *canthoplasty*, in which an incision is made extending outward from the outer canthus (see Fig. 34), and

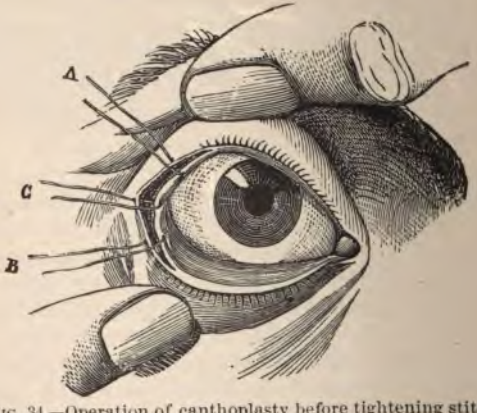

FIG. 34.—Operation of canthoplasty before tightening stitches.

the skin and conjunctiva are brought together by three sutures, one for the upper lid, A, one for the lower lid, B, and one at the junction of the lids, C. By the separate healing of the two lids the palpebral fissure is thus permanently widened.

What is ankyloblepharon?

An adhesion of the margins of the upper and lower lids, causing partial closure of the palpebral fissure; the advisability of attempting a separation of the lids depends on the probability of freedom from adhesions of the lid to the globe, as indicated by the apparent freedom of movement of the eyeball beneath the lids.

What is symblepharon?

The union of the conjunctiva lining the lids with that covering the eyeball, usually by bands or masses of cicatricial tissue left after burns of hot metal, quicklime, or acids. When it causes marked deformity, or impairs the usefulness of the eye by hindering its movements or preventing a sufficient separation of the lids, it calls for operation. The great obstacle to its relief is its tendency to recur with cicatrization after any operative interference. A shield usually of glass or metal worn between the lids and the eyeball may keep the parts in better position for healing and prevent the formation of adhesions during the early days after injury; but it will not prevent the contraction of cicatricial bands that form between the globe and the lids.

How can symblepharon be cured?

Narrow bands or adhesions that are isolated and do not extend to the junction of the lids and globe may simply be divided. In cases of more extensive adhesion the lid is to be dissected from the globe, and the raw surfaces thus made on the inside of the lid and eyeball carefully covered by mucous membrane from the patient's lower lip.

What is entropion?

A turning in of the lid or lid margin so that it presents the lashes toward the conjunctival surface of the other lid, or toward the eyeball itself. It may be due to spasmodic contraction of the orbicularis muscle, *spasmodic entropion;* to relaxation of the skin of the lid, as is seen in old people, *senile entropion;* or to cicatricial contraction of the conjunctiva, or the cartilage and other tissues of the lid, *cicatricial entropion.* This last may arise from burns or wounds of the lid, but is more frequently due to cicatricial changes following trachoma.

How is entropion to be treated?

The spasmodic contraction may arise from the use of the bandage, or from some acute swelling of the lid. It is then cured by removal of the cause. When it is due solely to relaxation of the skin, removal of a sufficiently wide lens-shaped strip of skin parallel with the lid margin may be all that is required, but when it is due to cicatricial contraction, a well-planned operation will be necessary to give relief. Entropion of the lower lid may be relieved by cauterizing the skin in a line parallel to the lid margin, and at least 4 mm. away from it, with a point of caustic potash.

What is the operation for entropion of the upper lid?

One that draws up the skin of the lid border and securely attaches it to the upper margin of the tarsal cartilage. The skin is put on the stretch and an incision made parallel to the lid margin, and so far below the border of the cartilage that when drawn up to it the lid border will be pulled upon sufficiently to properly evert the lashes. A strip of tissue down to the cartilage, including skin and muscle, is removed, and three sutures are passed: first, through the skin near the lid border; then through the upper margin of the cartilage; and, finally, through the upper lip of the wound. When these are drawn upon and tied, the lid border will usually be brought into proper position. This is essentially the operation recommended by Hotz. In bad cases it may be necessary also to split the lid border by an intermarginal incision, which is placed just back of the bulbs of the lashes, and to introduce into it a thick or wedge-shaped skin-graft as long as the incision; this graft may be taken from just behind the ear.

What is ectropion?

An eversion of the lid by which a portion of its conjunctival surface becomes exposed. It may be due to swelling of the conjunctiva, to relaxation of the orbicularis muscle, or to the contraction of a cicatrix involving a part of the lid, or some attached tissue. If from the first cause, reduction of the swelling is all that is required; if from the second, the treatment of the resulting epiphora is sufficient, but cicatricial

ectropion often requires a well-planned plastic operation. Of such operations many have been devised, either to bring in adjoining tissue, to bring a flap with a pedicle from a greater distance, or to transplant a piece of skin bodily from some distant part to fill in the space left by dissecting out the cicatrix. For ectropion of the lower lid due to relaxation, a V-shaped piece of the proper size may be taken from the lid near the outer canthus, and the two sides of the cut brought together by sutures. Where the tendency to ectropion is but slight, it may be remedied by careful massage of the cicatrix causing it.

What is epicanthus?

A congenital deformity in which there seems to be too much skin for the bridge of the nose, so that it is seen on either side in a fold that overhangs the inner canthus and conceals it. Usually this deformity will disappear entirely as the nose develops, but if it does not, it may be corrected by removing a lens-shaped piece of the skin from each side of the bridge of the nose.

What are trichiasis and distichiasis?

Displacements of the lashes, which are important, as these are turned in against the cornea or conjunctiva. In trichiasis the lashes are wrongly directed. In distichiasis it is supposed that an extra row of lashes exists, which are turned against the eyeball. When few, the misdirected lashes may be pulled out or destroyed by electrolysis. When numerous an operation like that for entropion, or the complete excision of the lashes, must be practised. The possibility of an ingrowing eyelash should be borne in mind in every case of recurring irritation of the eye.

What is pediculosis of the lashes?

The *pediculus pubis*, or crab-louse, sometimes infests the lashes. The ova are pear-shaped, yellowish bodies, 1 mm. long, each fastened to a lash. The adult louse is somewhat larger, flat, oval, gray, and lying close to the skin. It is difficult to see. Cleansing of the lashes and rubbing in of yellow oxid of mercury ointment (1 : 60 or stronger) will soon destroy the parasites.

LACRIMAL APPARATUS.

What is epiphora?

The condition of the eye in which the tears accumulate and tend to run over the margin of the lid. Strictly speaking, it should be applied only to the cases in which this occurs from excessive secretion, *stillicidium lacrimarum* being the term to indicate watery eye from interference with the escape of tears through the natural channels.

What are the abnormal conditions of the lacrimal gland?

Inflammation, *dacryo-adenitis*, is very rare. If it suppurates and is allowed to discharge through the skin it may leave a *fistula*. The gland may undergo *hypertrophy*, or be the starting point of sarcoma. Occasionally, as a congenital peculiarity or from traumatism, it is *dislocated* from its usual position, where it is concealed by the margin of the orbit, and appears as a more or less movable tumor of the upper lid. It has been extirpated without causing undue dryness of the conjunctiva.

What results from eversion of the punctum?

Normally the punctum is kept in close apposition to the eyeball, and in this position it continually receives the tears and carries them off, preventing their accumulation. Sometimes as a congenital peculiarity, more frequently from swelling of the conjunctiva, or from senile relaxation of the orbicularis muscle, the punctum gets turned slightly away from the eyeball, and presents directly upward on the free margin of the lid; in this position the tears can only enter it after the eye has filled, and they are commencing to run over the edge of the lid, and a more or less constant watering of the eye results. Sometimes the upper punctum remains in normal position and is able to carry off the secretion except when it is increased, as by exposure to bright light, wind, or dust.

What is to be done for eversion of the punctum?

If due to temporary swelling of the conjunctiva, treating that may cure it. Otherwise the canaliculus must be opened from the punctum, well down on the inner side of the lid. To do this little operation cocain should be used, the lid should

be strongly everted, and a probe-pointed canaliculus knife, Fig. 35, introduced in the punctum, with the cutting edge turned toward the eyeball, and pushed along the canaliculus until a sufficient part of the inner wall of the passage has been

FIG. 35.—Knife for slitting the canaliculus.

divided; the edges of the incision must then be separated each day by traction on the lid, or with a probe, until they heal without reuniting.

What is lacrimal obstruction?

The checking of the free passage of the lacrimal secretion through the lacrimal passages into the nose, by narrowing of the punctum, by swelling of the mucous membrane, by stricture through fibrous thickening of the submucous tissue, or by narrowing of the bony canal from disease of the neighboring bone.

What are the symptoms of lacrimal obstruction?

The eye is constantly full of tears which must be wiped away or they run over the cheek. Often there is a notable fulness of the region of the inner canthus, and pressure here causes the contents of the lacrimal sac to regurgitate through the puncta. If the obstruction is complete the contents of the sac soon become mucopurulent; and as they are frequently caused to flow out back into the eye they infect the secretion in the conjunctiva, and so set up a conjunctivitis.

What are the dangers of lacrimal obstruction?

The annoying overflow of tears will be aggravated by use of the eyes, or exposure to bright light, cold, wind, dust, etc. The contents of the sac always become a culture-medium for pathogenic bacteria; and the slightest lesion of the cornea is likely to become a source of dangerous infection which may cause loss of the eye.

What is the treatment for lacrimal obstruction?

If congenital, it may be due to incomplete development of

the lacrimal passages, and frequent pressure on the sac, forcing out the contents and tending to open the passage into the nose, will in a few days or weeks generally secure a free passage; the cure thus effected is complete and permanent. In older patients, the attempt should be made to force solutions through into the nose with the lacrimal syringe. Solutions of trikresol and protargol tend to improve the condition of the mucous lining of the sac. Cocain or adrenal extract may, by diminishing swelling, aid in securing a free passage, but these latter should be thoroughly washed out of the sac before letting the patient go. If the passage of a solution into the nose is thus secured, repeated injections may effect a cure, but if the obstruction has continued some months, and after a few trials it is found that fluid cannot be forced through into the nose, more radical measures must be adopted.

How should the sac be opened and treated?

One of the canaliculi should be opened as for everted punctum, but with care to carry the knife quite into the lacrimal sac. It is better to open the upper canaliculus unless the lower punctum be distinctly everted. In either case the slit must be made well on the inner surface of the lid. The sac should then be thoroughly washed out with one of the solutions before mentioned. Radical measures for opening the passage into the nose may then be carried out, or, if time is not important, two or three days may be allowed to diminish the soreness of the part which follows this first interference.

What are the lacrimal probes?

A series of curved probes made of silver or aluminum, which vary in diameter from ½ to 4 mm.; of the so-called Bowman's probes, the largest, No. 8, is 1.25 or 1.5 mm. in diameter; the Theobald probes run up to No. 16, 4 mm. in diameter, with ½ mm. intervals between the successive numbers. The smaller probes are useful for purposes of exploration; the larger ones to produce disorganization and absorption of exudates within the lacrimal canal. It is important that these should be smooth and have somewhat tapering ends.

How are lacrimal probes to be used?

After the canaliculus has been opened and the sac washed

out, a strong solution of cocain should be injected into the sac, to diminish the pain of the operation and produce contraction of the mucous membrane, so as to facilitate the entrance of the probe into the narrowed lacrimal duct. A probe of moderate size (No. 8 Bowman or No. 9 Theobald) is then to be entered in the slit canaliculus, and pushed forward until its end comes in contact with the inner wall of the sac against the nasal bone; the free end of the probe is then to be raised

FIG. 36.—Introduction of a lacrimal probe (Meyer).

until the lower end points directly downward, or a little forward, and a little from the median plane of the head; then, holding it lightly between the thumb and finger, the probe is pressed down until the obstruction is reached. By seeing that it is properly directed and by a slight lateral movement the surgeon must assure himself that the point is really entering the lacrimal duct; then, by a steady pressure in the direction of the point, it is to be pushed downward, the pressure being

gradually increased until it begins to move, and continued until the patient complains that he feels the end of the probe in the nose, or until the length of probe that has entered indicates that its point has passed out of the duct into the nose.

How should the probing be continued?

The probe should be left in position twenty or thirty minutes. At the end of two or three days a probe one or two sizes larger is to be passed in the same way, usually it will encounter less resistance than did the smaller one; this is to be repeated at intervals of two or three days, with probes successively larger, until decidedly greater resistance is noticed. This mostly occurs when Nos. 12 or 13 Theobald are used; it means that the caliber of the bony canal has been nearly reached and the use of larger probes will endanger its walls. The largest that can be passed without encountering the resistance of the bony walls should then be used every three or four days until it passes quite easily; then the interval should be lengthened to one week, two weeks, and a month; at the end of six months the patient may go six months without probing, then, if no material contraction of the canal is found, the case may be regarded as cured. Only patients who can be relied on to persist with the treatment should be subjected to probing.

What is the lacrimal style?

A piece of lead or silver wire the size of a lacrimal probe, worn in the passage to keep it open. It must be removed frequently for cleansing.

What is abscess of the lacrimal sac?

Dacryocystitis is a name applicable to any inflammation of the lacrimal sac; but if the inflammation be violent it involves the neighboring cellular tissue, forming a true abscess, which tends to open through the skin, to become chronic, and leave a lacrimal fistula, which it will be very difficult to heal unless free drainage is secured through the lacrimal canal.

When should the lacrimal sac be excised?

When there is chronic obstruction with infection of the sac, as shown by discharge of muco-pus or lacrimal conjunctivitis, and the patient will not submit to a full course of probing or cannot remain long enough under treatment; or when there is chronic lacrimal abscess or fistula and other treatment has proved ineffective.

How is the sac excised?

An incision three-fourths of an inch in length is made parallel to the side of the nose half way between the nose and the inner canthus, down to the sac; which is recognized by its pale or bluish color and smooth appearance. The upper end of the sac is dissected out, and the dissection continued down into the canal as far as possible and the sac cut off. Remaining portions of mucous membrane, and diseased bone should be curretted.

DISEASES OF THE CONJUNCTIVA.

What are the causes and symptoms of hyperemia of the conjunctiva?

Foreign bodies, air loaded with dust or smoke, eye-strain, excessive weeping, or the attempt to use the eyes when very tired, will cause burning, smarting, a feeling of "something in the eye," photophobia, and the excessive secretion of tears. On inspection the vessels on the inside of the lid are found enlarged and prominent, the tissue between them remaining normally transparent, and sometimes the same condition extends to the vessels on the eyeball, causing the "blood-shot" appearance. Certain constitutional states and the use of alcoholic beverages may also cause it.

When and how should hyperemia of the conjunctiva be treated?

If the cause be quite temporary the hyperemia will disappear with it, in a person otherwise healthy; if the cause be persistent, as eye-strain from ametropia or presbyopia, it must be carefully sought out and corrected. When there is some underlying dyscrasia it is often best, in addition to constitutional remedies, to employ local stimulants, as the yellow ointment, or the glycerol of tannin, brushed on the inner surface of the lids. To relieve the local sensations of irri-

several drops of a solution of boric acid, with or without borax, should be instilled every three hours or oftener. The addition of holocain to such a solution (2 grains to the fluid-ounce) adds to its efficiency, both in relieving discomfort and in curing the disease, but cocain should not be used for this purpose.

What is the character of the pain of conjunctivitis?

It is of a smarting, scratching, burning character, strictly local, and only accompanied with true aching when there is very considerable swelling of the lids.

Describe the redness of conjunctivitis.

It is generally most pronounced on the inner surface of the lids, becoming less as the conjunctiva passes over on to the

FIG. 37.—The hyperemia of acute conjunctivitis.

globe, and being least near the margin of the cornea (see Fig. 37). Redness is marked in proportion as the hyperemia of the part preponderates over the exudate into it. A proportionately great amount of exudation masks the enlargement of the vessels and causes the surface to appear as pale as the normal, or even paler.

Describe the swelling of conjunctivitis.

One of the first effects of exudation into the tissue is the concealment of the separate vessels which are so apparent in the normal conjunctiva. Sometimes, however, when the exudate is excessive, it is itself translucent, having the appearance of jelly, in which a few of the vessels widely separated

by it may be seen. The swelling is usually greatest in the lids; relatively great swelling of the conjunctiva covering the globe is indicative of disease within the globe. An edema of the ocular conjunctiva, causing it to rise up like a wall around the cornea or to overhang it, is called *chemosis.*

Is there always discharge with conjunctivitis?

Yes; but it may amount to little more than an increase in the amount of epithelium and normal secretion thrown off. A slight discharge often becomes noticeable in the morning, when by accumulating on the lashes all night and drying there, it causes the edges of the lids to adhere, so that there is difficulty in opening them. Even when considerable, it may be so diluted with an excess of lacrimal secretion that its character is not distinguishable. When present in considerable amount it is of mucopurulent character, becoming more purulent as the amount increases. In some cases it is very irritating to the outer surface of the lids where it comes in contact with them.

What is simple or acute catarrhal conjunctivitis?

An inflammation produced by local irritation, eye-strain, the constitutional conditions that cause acute catarrhs of other mucous membranes, or by infection. It is characterized by conjunctival hyperemia and moderate exudation, causing some impairment of the transparency of the conjunctiva and some discharge of a mucopurulent character; if not aggravated by poulticing or other improper treatment, or kept up by a peristent cause, it will run its course in a few days to complete recovery. Sometimes it is complicated by the occurrence of superficial ulcers near the margin of the cornea, which alter the distribution of the hyperemia and make the pain more severe without changing its character.

What bacteria occur in the discharge of simple conjunctivitis.

The white staphylococcus is usually found in the normal conjunctiva and on the lid margins, and the so-called xerosis bacillus, a form of pseudodiphtheria bacillus resembling very closely the true diphtheria bacillus, is also very frequently found in the normal conjunctiva. Either of these is likely to be seen

in the discharge of simple conjunctivitis, often in enormous numbers. It is quite likely that their increase and activity is a factor in producing such attacks. Streptococci and many other forms of bacteria liable to infest the conjunctiva may also be found.

How should simple conjunctivitis be treated?

By removal of all irritants, rest of the eyes, including sufficient sleep, the careful avoidance of any bandage or other covering that will favor hyperemia; and by frequent instillations of a solution of boric acid and borax, or holocain and boric acid or of argyrol. If there is much discharge a 1 per cent. solution of silver nitrate should be applied to the inner surface of the lids, and the application repeated one or more times on successive days if necessary.

How do you apply a solution to the inner surface of the lids?

Twist a bit of absorbent cotton around the end of a probe or, better, a small stick, as a wooden tooth-pick or match-stick, so that while it will adhere to the stick the end is left fluffy; evert the lid, and having dipped the cotton into the solution, brush the conjunctival surface with it, allowing the patient to look down to expose the upper lid, and up to expose the lower. Before allowing the lids to return to their normal position, the upper lid may be drawn well down, and the lower lid, still everted, pushed up underneath it as far as possible; in this way the solution may be brought in contact with a portion of the upper lid that is otherwise inaccessible, the lower lid carrying the application to it. If it is designed to have the application of full strength, the cotton is to be used just ready to drop with the solution, but a very much milder application is made by first pressing out all excess of the solution against the side of the bottle.

What is pneumococcus conjunctivitis?

The pneumococcus as the principal organism, or in almost pure culture, is found in many cases of acute conjunctivitis. It appears to be the cause of some endemics, especially in boarding-schools. The symptoms closely correspond to those of simple acute conjunctivitis. It is probably the active

by it may be seen. The swelling is usually greatest in the lids; relatively great swelling of the conjunctiva covering the globe is indicative of disease within the globe. An edema of the ocular conjunctiva, causing it to rise up like a wall around the cornea or to overhang it, is called *chemosis.*

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in a few days cases that have resisted other treatment for months. Solutions of zinc chlorid ($\frac{1}{5}$ of 1 per cent.) and of protargol (2 per cent.) have also proved efficient.

What is chronic catarrhal conjunctivitis?

Repeated attacks of acute conjunctivitis, especially if neglected, give rise to a permanent condition characterized by thickening of the epithelial layer and swelling of the subconjunctival tissue. The surface may be smooth or may present fine elevations due to swollen papillæ. There is usually a great deal of smarting complained of by old persons, who are particularly liable to this form of disease. Diplobacillus conjunctivitis if not efficiently treated may become chronic.

What is the treatment for chronic catarrhal conjunctivitis?

See that the patient is using the best glasses, and if they have heretofore been used only for near vision distance-glasses also may be required. Much relief is usually afforded by astringent applications, but nitrate of silver if continuously used for too long a period will discolor the conjunctiva; a smooth crystal of alum may be passed over the surface; solutions of zinc sulphate are very useful for the diplobacillus cases. Glycerol of tannin and protargal are serviceable. It is best to vary the application from time to time.

What is vernal conjunctivitis?

A peculiar inflammation of the conjunctiva that grows worse with the warm weather in the spring, usually gets better with the cool weather of autumn, and tends to recur for several years in succession. It affects children, usually involves both eyes, is but little benefited by treatment, and is marked by a thickening of the conjunctiva at the corneal margin while the inner surface of the lids has the appearance of being covered with a thin milky film, or by firm broad granulations. It may persist through the winter.

When is a conjunctivitis called purulent?

When it commences with great swelling of the lids and chemosis, and after one or two days a free purulent discharge is set up, which continues for some weeks, while the swelling gradually lessens. It is due to infection, and when it can be

directly traced to a case of gonorrhea, it is called *gonorrheal ophthalmia.* Even where no history of contamination can be obtained, the gonococcus is commonly found in the discharge, but in some cases the common colon bacillus, the streptococcus, or other pathogenic bacteria appear to be the cause.

What is the danger of purulent conjunctivitis?

The great danger of the disease is from involvement and partial destruction of the cornea. It tends ultimately toward complete recovery, but requires a month or more to run its course; and may leave a chronic condition of hyperemia with enormous enlargement of the conjunctival papillæ.

How should purulent conjunctivitis be treated?

First secure strict cleanliness of the conjunctiva by frequent cleansing with a solution of potassium permanganate, boric acid, or salt solution or with warm water. This must be used with extreme gentleness, but in quantity sufficient to remove all conjunctival discharge. A 20 per cent. solution of argyrol or a 5 per cent. solution of protargol should be dropped in the eye freely every four hours, or once daily an application of a solution of silver nitrate, of the strength of 2 per cent. or upward, should be made to the everted lids, or if the swelling and discharge are very great, this should be dropped into the eye, and by manipulation carried to all parts of the conjunctival sac. Early in the disease the continuous application of cold to the lids by iced cloths may influence it very favorably; but later, and especially if the integrity of the cornea is threatened, cold applications must be avoided; the eye may then be bathed for a few minutes at a time every three or four hours with very hot water. At the height of the attack the patient had better remain in bed, and take full tonic doses of tincture of iron and quinin.

How can infection be kept from the second eye?

The efficient treatment of the diseased eye speedily renders its discharge less dangerous. But at first it may be important to keep the sound eye closed with an absorbent-cotton dressing, or even sealed up under a watch-glass, fastened on with

collodion or adhesive plaster, the so-called Buller's shield. In all cases, the patient should be warned against carrying the infection from one eye to the other with the fingers or handkerchief.

What is ophthalmia neonatorum?

A purulent conjunctivitis of early infancy due to infection of the eyes at birth, though often attracting but little attention for the first few days. It is the most common cause of life-long irremediable blindness, through perforation and resulting opacity of the cornea. The discharge glues together the edges of the lids, preventing its own escape, until the conjunctival sac may become enormously distended with it, and soaking day after day in this mass of infectious pus, the cornea is apt to become softened and give way. Still, the cornea at this age has great resisting and reparative power, and with the aid of active treatment can almost always be saved if it be not already damaged before such treatment is instituted.

What is the treatment of ophthalmia neonatorum?

To prevent it drop a 2 per cent. solution of silver nitrate or a 20 per cent. solution of argyrol into the eyes of every child born of a mother known to have suffered with gonorrhea or having a suspicious vaginal discharge. If the disease is established, follow out the local treatment given for purulent ophthalmia with the greatest care, making sure that each application and cleansing is thorough.

What is croupous conjunctivitis?

A variety of conjunctivitis in which a part of the exudation remains slightly adherent to the conjunctival surface whence its separation is not difficult, but may cause some bleeding. The grayish mass gives the name to this condition. It does not constitute a specific form of conjunctivitis, but the croupous deposit may occur in either of the acute diseases above mentioned, especially in purulent conjunctivitis and diphtheritic conjunctivitis; it requires little special treatment, bathing with hot water is beneficial in promoting the separation of the croupous deposit.

What characterizes diphtheritic conjunctivitis?

The finding of the Klebs-Löffler bacillus in the exudate. Very careful culture- or inoculation-experiments are necessary to differentiate this from the pseudodiphtheria "xerosis" bacillus; as these require time, the loss of which would be liable to cause the loss of the eye, it is safer to proceed at once to treat any urgent case upon the indications of a clinical diagnosis. In the typical cases there occurs a firm, fibrinous exudation, not to be detached from the surface of the conjunctiva, but partially within the tissue of the lids, which are greatly swollen, stiff, and brawny. This condition lasts for some days and gives place to the conditions of an ordinary purulent conjunctivitis. The cornea is liable to be destroyed and there may be cicatricial contraction of the lids.

What is the treatment for diphtheritic conjunctivitis?

The prompt employment of the diphtheria antitoxin. This should be injected in full dose at the earliest possible moment, and the injection repeated in twenty-four hours or at shorter intervals until it is demonstrated that the case is not diphtheritic, or until the lids have become softened and improvement in other respects is well marked. Locally, frequent hot applications should be used and the conjunctiva cleansed of all discharges. It has been demonstrated that the toxins alone are quite capable of destroying the cornea.

What is trachoma, or granular conjunctivitis?

It is a specific inflammation arising by contagion, sometimes very difficult to trace, but most likely to occur under conditions of overcrowding and lack of cleanliness, especially in orphan asylums and the steerage of ocean steamers. It is probably due to some micro-organism which has not been identified. It is characterized by the occurrence of translucent granular masses beneath the conjunctival surface; these are found both on the inner surface of the lids and in the retrotarsal folds of the conjunctiva. These granules are composed at first of leukocytes, but later become organized into firm fibrous tissue; their appearance is aptly compared to that of sago grains (See Fig. 38). They are much larger and deeper

than the slight elevations of surface often seen in catarrhal conjunctivitis, due to swelling of the papillæ, that are popularly spoken of as "granulated eyelids." They are also to be distinguished from the superficial hard flattened granulations of vernal conjunctivitis and the deep red, soft, granulations of purulent conjunctivitis. The cornea is threatened, not with perforation, but with permanent opacity from pannus; there is but little tendency to spontaneous recovery, and the lids are always left the worse for cicatricial contractions.

FIG. 38.—Trachoma, a true granular lid (after Nettleship).

How is trachoma to be treated?

The destruction of the individual granulations should be thoroughly accomplished, preferably by the use of the Knapp roller-forceps, with general anesthesia. If they are few it may be done by electrolysis, by the galvanocautery, or by incising each separate granulation and expelling its contents by pressure. In addition to operative treatment, or where it is not necessary, strong astringent applications should be made to the conjunctiva daily. For this purpose the copper crystal, the glycerol of tannin, and a solution of iodin in glycerin or petrolatum are the most valuable; but they require to be varied with others, such as silver nitrate, alum crystal, and solutions of zinc sulphate; the mercuric-chlorid or trikresol solution should also be used three or four times a day to cleanse the conjunctival sac. Great care should be taken to avoid the infection of the second eye where only one is affected, or the infection of the eyes of other persons with whom the patient comes in contact. The treatment, too, must be persistently carried out for a long time, sometimes many months, or even years, until the disease is eradicated. Its earlier suspension may be followed by relapse and the indefinite continuance of the disease. Even with proper treatment a return to the original normal condition of the lids cannot be hoped for, some cicatricial shrinking of the conjunctiva, and often of the deeper tissues of the lid, must be expected.

Frequently, too, the disease leads to pannus, and may require the special treatment referred to under that head.

What should be done to prevent the spread of trachoma?

Its contagious character should be recognized, and every case so supervised as to prevent any liability to infect others from the ocular discharges. The risk of spreading the disease is greatly reduced by efficient local treatment, but care to provide separate wash-basins, towels, handkerchiefs, etc. must be observed and, so far as possible, the patients should be isolated. Overcrowding, as in the steerage-passage across the ocean, frequently causes the spread of the disease. The hands of the surgeon and instruments used in the treatment of trachomatous eyes must be cleansed with scrupulous care.

What is chronic membranous conjunctivitis?

A rare form of disease in which a portion of the conjunctiva becomes covered with a whitish false membrane, firmer than the usual croupous deposit, and leaving a raw surface when removed. There may be slight swelling and little other evidence of inflammation, but the membrane tends to persist for many months or even for years. The condition is probably not connected with the diphtheria bacillus, although this or the xerosis bacillus has at times been found in eyes thus affected. Many kinds of treatment have been tried without decidedly beneficial results.

What is Parinaud's conjunctivitis?

A disease marked by great swelling of the lids, polypoid granulations of the conjunctiva, and involvement of the related lymphatics. The onset is severe and attended with rigors and general depression; the pre-auricular, submaxillary, and cervical lymphatic glands are markedly swollen and may suppurate. Cutting off the larger granulations and cauterizing their bases seems to be beneficial; other treatment has little effect, but the case goes on to slow recovery.

What is ophthalmia nodosa?

An inflammation of the conjunctiva and sometimes of the cornea and iris, marked by rounded gray swellings, and tending to long continuance with repeated relapses. It is caused

by the presence of caterpillar hairs, one or more of which may be found in each of the swellings. Excision of the foreign body brings prompt recovery.

What is brief recurring episcleritis?

A painful hyperemia of the conjunctiva and episcleral tissue without discharge. The attack lasts for a few days, appearing suddenly and gradually diminishing, but it is repeated after an interval of weeks or months, and the liability to such attacks has been known to continue many years; it seems to depend on conditions of the general nutrition.

What is pterygium?

A triangular thickening and extension of the conjunctiva and subconjunctival tissue on the cornea (see Fig. 39); the

FIG. 39.—Pterygium (after Meyer).

apex of the triangle is toward the center of the cornea, the base usually toward the inner canthus, sometimes toward the outer canthus, and very rarely in other directions. It is most common in warm and dusty countries; it continues for a certain time progressive, and then may remain stationary for an indefinite period; it is unsightly, and may impair vision by encroaching on the space of the pupil, or by causing astigmatism.

What is to be done for pterygium?

If not extending its area upon the cornea it may be left undisturbed, but if the corneal portion be increasing it should be removed. To do this, seize the apex with strabismus-forceps and draw upon it. Then with a knife separate the over-

lying tissue from the clear cornea, being careful to remove it all, leaving nothing but the transparent corneal tissue. Continue the incision until the extracorneal part of the pterygium is also separated from the sclera for some distance back from the corneal margin. The mass thus isolated may be disposed of by either of the following methods: It may be excised by two cuts with the scissors, starting from the cornea at the upper and lower edges of the pterygium, and converging until they meet near the caruncle.

It may also be caused to atrophy by transplantation, by making an incision from the lower border of the pterygium below the lower margin of the cornea, and fixing the corneal portion of the growth in this position by a suture. Still better is the McReynolds method. The conjunctiva is undermined below the pterygium, and a suture passed through the apex of the growth. Both ends of the suture are passed under the conjunctiva, and brought out and tied $\frac{1}{2}$ or $\frac{3}{4}$ of an inch below the cornea. Pterygium often recurs after removal and may limit ocular movements and cause diplopia. Scars following operation may also interfere with the lateral movements.

What is pinguecula?

A yellowish thickening of the conjunctiva and subconjunctival tissue at the inner, or rarely the outer, margin of the cornea. When inflamed it may be quite prominent, and if annoying to the patient may be excised. It has no tendency to spread upon the cornea or to prove otherwise injurious.

What are Meibomian concretions?

Masses of the secretion of the Meibomian glands which may in time become calcareous; they appear as yellowish-white spots of the size of a pin-head beneath the conjunctiva of the lids. When they give rise to irritation they should be removed.

What is subconjunctival ecchymosis?

The effusion of blood beneath the conjunctiva. Small effusions occur in all severe conjunctival inflammations. Large ones, sometimes requiring several weeks for their removal, are due to disease of the vessels or to straining in coughing, vomiting, etc. They are especially frequent in connection with whooping-cough.

What are the appearances and treatment of tuberculosis of the conjunctiva?

The lids are swollen and their conjunctival surface presents superficial patches or nodules of red, or yellowish-gray or white, which tend to break down and ulcerate. Tubercle-bacilli are often very difficult to find. They are best demonstrated by inoculation experiments. The lymphatic gland in front of the ear is affected early. The disease runs a very chronic course. The treatment is complete excision of the diseased tissue, destruction with the galvanocautery or very thorough curetting under general anesthesia, followed by the application of strong carbolic acid and subsequent dressing with iodoform.

What other morbid conditions affect the conjunctiva?

Amyloid degeneration usually affects the inner surface of the lid, causing a pale waxy appearance and considerable thickening. It is a strictly local process, the tissue involved may be removed by scraping. *Pemphigus* occurs in the conjunctiva in cachectic patients who usually suffer from pemphigus of the skin. Isolated spots of the conjunctiva lose their epithelium and shrink. Adhesions form between the bulbar and palpebral portions of the membrane until the conjunctival sac is obliterated, the lids bound closely to the globe and sight lost. In *xerosis* the conjunctiva becomes contracted and dry with gray scales on the surface. *Dermoid tumors* are usually situated at the margin of the cornea or partially upon it. They are smooth, of a yellowish color, resemble the skin in structure, and sometimes present fine hairs growing from the surface; they require removal. *Simple polypus, sarcoma, epithelioma, papilloma,* and *syphilitic ulcers,* both secondary and primary, occur upon the conjunctiva. It may be the seat of pigment deposits.

What diseases affect the caruncle?

It is subject to chronic non-inflammatory enlargement called *encanthis.* Rarely it is the seat of *abscess;* it becomes red and swollen in connection with conjunctivitis. Occasionally short *hairs* spring from it, which may cause intense itching and irritation by coming in contact with the eyeball or inner surface of the lid.

What is phlyctenular or strumous ophthalmia?

An inflammation always involving the conjunctiva, and often the cornea, dependent largely on a certain constitutional condition or upon disease of the nasal passages, occurring usually in children presenting repeated exacerbations or attacks, which tend to rather speedy recovery, but which may in the end leave the cornea seriously damaged, and which are characterized by the appearance of phlyctenules, usually at the corneal margin or limbus of the conjunctiva, or upon the cornea.

Describe a phlyctenule.

On the conjunctiva it appears suddenly, that is, in a few hours' time, as an elevated patch from one to three millimeters in diameter, which patch after a day or two has an abraded surface, but continues elevated throughout (see Fig. 40). It gradually subsides after a few days, being followed by a complete restoration of the part to its normal appearance. On

FIG. 40.—Phlyctenular ophthalmia.

the cornea it begins as a minute elevation of the surface epithelium, which is soon lost, allowing the escape of a drop of fluid, and the ulcer so formed slowly heals, leaving a gray cicatrix that becomes more like normal corneal tissue as the child grows older, and may become quite imperceptible, except by its interference with the proper refraction of light.

Describe the hyperemia of phlyctenular ophthalmia.

When the conjunctiva alone is the seat of phlyctenules, only

the conjunctival vessels are involved, and mainly those running to the particular part or parts where the phlyctenules are seated; this causes the white of the eye to be reddened in one or in certain directions, while other radiating sectors may have the normal color. If one is situated near the margin of the cornea, there will be a pink zone of hyperemia of the deep vessels, but it will be mainly or entirely confined to that side of the cornea. If the phlyctenule be at the center, or if there be several on various parts of the cornea, the pericorneal zone will extend all round. This hyperemia of the surface of the globe is so obvious that it cannot escape notice; it becomes very marked with each fresh eruption of phlyctenules and quickly fades away again. But there will also be found a hyperemia of the inner surface of the lids, which is worse during the attacks, but which persists during the intervals, and requires that the local treatment for it be kept up until it is completely cured, if immunity is to be had from future exacerbations of the disease.

What are the other symptoms of a phlyctenular attack?

There is much of the usual smarting, burning pain of a conjunctivitis, and in many cases, especially those involving the cornea, a very strong inclination to keep the lids tightly closed. This is spoken of as photophobia, but it is not a simple dread of light. Primarily it is more a dread of having the cornea exposed to the air; and the eyes will be as tightly closed and the head as deeply buried in the pillow in complete darkness as in ordinary light. When, however, the exclusion of light has been permitted for a few days, a true photophobia is added. The spasmodic closure of the lids is probably due to the corneal lesion, but it may be increased or continued by an abrasion or *fissure of the skin* at the outer canthus, which is brought about by the continuous overflow of tears at this point that goes on when the lids are kept violently pressed together, and which, when once formed, may act as a source of reflex irritation. Excessive lacrimation is a symptom generally present, and the slight increase of mucous secretion is so diluted and washed away as not to be recognizable.

How should phlyctenular ophthalmia be treated?

Strict attention should be paid to general hygiene, especially to secure outdoor life a considerable part of each day, the prevention of constipation, and the careful regulation of diet. It is often necessary to instruct parents as to the harm of the free use of tea and coffee, the taking of sweets between meals, and the inability of the stomach of a delicate child to deal with certain foods. Of general tonics, preparations of the iodid and chlorid of iron are most valuable. Locally, anything like a poultice or bandage must be strictly avoided. It is sometimes worth while to order the use of dark glasses to prevent the constant rubbing and wiping of the eye. The strong astringents, like silver, zinc, and tannin, are only to be used for lightly brushing the inner surface of the lids. The ointment of the yellow oxid of mercury should be used once a day. If the cornea be much involved, atropin instillations will lessen the irritability. Treatment should not be intermitted in the interval between the attacks, but continued until the liability to them is quite removed. The condition of the nose should be carefully looked into, any abnormality corrected, and rhinitis efficiently treated. Opacities of the cornea are to be treated after methods to be presently described.

DISEASES OF THE CORNEA.

What hyperemia attends inflammation of the cornea?

The blood-vessels on which the nutrition of the cornea depends being situated, not in its substance, but in a zone

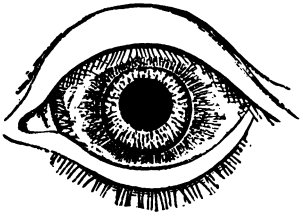

FIG. 41.—Pericorneal zone of hyperemia.

around it, the hyperemia manifests itself in this zone. Nor-

mally these vessels are quite invisible, but when the cornea is inflamed their enlargement causes the appearance of a pink or rose-colored zone, most deeply colored at the corneal margin, and shading off gradually into the white sclerotic (see Fig. 41); this may be of equal width all around the cornea, or it may be narrower or quite absent at some parts of the corneal circumference. The same pericorneal zone is seen in iritis and in inflammation of the ciliary body; it is to be carefully distinguished from the redness due to conjunctivitis, which is deepest where the conjunctiva passes over from the lids on to the eyeball, and may fade out entirely toward the cornea, and which involves the superficial vessels. It should be remembered that the two kinds of hyperemia not infrequently co-exist.

What are the other symptoms of keratitis?

The pain may be either of the burning or smarting character experienced in conjunctivitis, or it may be an aching, or both kinds may be felt. There is also dread of exposure to the light and air, and excessive lacrimation. The cornea to a greater or less extent loses its transparency by infiltration, causing obscuration of the red reflex from the fundus, as seen with the ophthalmoscope, a gray or translucent appearance by oblique illumination; and hiding or apparent altering of the color of the iris as seen through it. The surface of the cornea may also lose its normal regularity, either by loss of substance forming an ulcer, or by cicatricial contraction drawing it out of shape.

What is a simple or non-suppurating corneal ulcer?

The condition produced by the loss of a portion of the epithelium and deeper true corneal tissue. It is best recognized by examining the reflection of a window or a lamp-flame given by the cornea, and moving the point of view, or the light, or the eye under inspection, so that the reflection shall be successively received from all different parts of it. The extent of the ulcer is often best revealed by instilling a drop of fluorescin solution, which stains green the portion of the cornea deprived of its epithelium. While the ulcer is increasing the tissue about it may remain almost entirely transparent, but

more commonly is somewhat gray. But as the loss of substance is repaired by tissue that is not transparent, the process of healing gives rise to considerable opacity, which afterward slowly lessens as the reparative tissue becomes more or less completely transformed into true corneal tissue.

What are the causes of corneal ulcer?

Direct injury, exposure to the toxins arising in certain forms of conjunctivitis, disease or injury involving the ophthalmic branch of the trifacial nerve, and constitutional states of impaired nutrition, as old age, starvation, exhausting fevers, and malarial poisoning.

What is neuropathic keratitis?

A condition caused by disease of the nucleus or the ophthalmic branch of the fifth nerve, and usually attended with ulceration. The sensibility of the cornea, when tested by touching it with a twisted point of absorbent cotton, is commonly found to be subnormal, *corneal anesthesia;* and there may be other evidences of the nerve-disease. Usually there is some general haziness of the cornea. The treatment includes protection of the eye from irritation by closure under a light dressing, and the instillation of a solution of atropin or eserin. After destruction of the Gasserian ganglion, the disease may be prevented by keeping the eye closed and protected for several weeks.

What are the peculiarities of the corneal ulcer occurring with herpes zoster ophthalmicus?

It appears during or after the height of an attack of ophthalmic or frontal herpes or zona; often confounded with erysipelas on account of the swelling and violence of the inflammation. It is most likely to occur if the skin of the nose is affected; it is usually complicated by interstitial inflammation of the cornea and of the iris; it runs a slow course and is not helped by active local treatment. In this as in neuropathic keratitis the sensitiveness of the cornea to touch is subnormal.

What are the characteristics of the malarial ulcer?

It occurs in patients that have otherwise manifested malarial

poisoning, is superficial, has the shape of an irregularly branching line, and requires a regular antimalarial treatment.

What is herpes of the cornea?

An eruption of small vesicles upon the cornea, which quickly become ulcers and may run together, forming a linear ulcer of considerable size. It usually occurs in connection with febrile diseases, especially those of the air-passages. Healing comes with improved general nutrition.

What are the other kinds of non-perforating corneal ulcer?

Dendritic or *mycotic ulcer* is named from its branching form or its mycotic origin. It should be treated by scraping, touching with the galvanocautery, or thorough rubbing with tincture of iodin.

Bullous keratitis is characterized by blebs that form on the cornea and rupture, leaving ulcers. These recur again and again, attended with severe burning pain and hyperemia. Eyes with nutrition damaged by previous disease or traumatism are likely to be thus affected. General tonics, with atropin and hot applications to the eye, constitute the treatment.

Filamentous keratitis is the name applied to cases of corneal ulcer from which hang minute threads of tissue or fibrin.

What is the treatment for simple ulcer of the cornea?

When due to conjunctivitis, either acute or chronic, it is essentially the treatment of the conjunctivitis. In so far as it is due to impairment of general nutrition, constitutional treatment is required, as rest in bed, good food, and tonics. In such cases, and in those due to nerve-disease (neuropathic and herpetic), the cornea must be protected from injurious influences, and healing must be favored by local warmth. To this end the eye may be covered with a thin bandage, which must be kept from becoming damp, so that it would act as a poultice. Or dry heat may from time to time be applied, or the eye occasionally bathed for a few minutes with water as hot as can be borne. Atropin, or eserin, which has a similar power of stimulating the nutrition of the cornea, may be instilled from one to four times a day. Holocain, in ½ or 1 per cent. solution, may be used in the same way. Be-

sides relieving pain, it exerts a beneficial influence on the healing of the ulcer. Such use of cocain would be dangerous. Strong astringents are to be avoided, except as they are indicated for the treatment of a causative conjunctivitis.

What happens when an ulcer perforates the cornea?

The aqueous humor escapes, and the lens and iris are pressed forward against the cornea, the pupil immediately contracting, so that usually it is the iris that is in immediate contact with the point of perforation. Lymph is then effused upon the iris and with it closes the opening, and the aqueous reaccumulates. After this, if the perforation is very small, the iris may, with the help of atropin for a central, or eserin for a peripheral perforation, be dragged away from the cornea; this is the best result possible. If the iris remains incorporated with the lymph that goes to make up the cicatrix, a permanent *anterior synechia* is formed. When the area of the perforation is large, as soon as the escape of aqueous ceases with the plugging of the perforation with iris and lymph, this plug bulges forward and tends to drag more iris into the opening, causing an *anterior staphyloma*, that tends to increase.

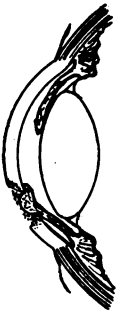

FIG. 42.—Results of perforating ulcer.

How should perforating ulcer be treated?

When threatened, the cornea should be tapped as a preventive, not through the bottom of the ulcer, but through some other portion. The operation is done by passing the point of a cataract-knife or a paracentesis-needle (Fig. 43) obliquely

FIG. 43.—Paracentesis-needle for evacuating the aqueous humor.

through the cornea, then rotating it so that it will spread the lips of the wound and allow the aqueous to drain slowly away, and then withdrawing the knife, taking especial care that the point shall at no time touch the capsule of the lens.

To perform this cocain may be used, but repeated applications of it should be avoided in all simple corneal ulcers. If perforation has occurred, strong solutions of eserin or atropin may be used to drag the iris loose, but if the cicatrix holds the iris and bulges with it, it should be excised, either by a single snip with the scissors, or by transfixing with a cataract-knife and shaving off one side and completing the removal with scissors. This operation must be repeated as often as the remaining cicatrix bulges, to secure parts of the cornea not involved in the ulcer from subsequent damage by increase of the staphyloma.

What is serpent or pneumococcus ulcer of the cornea?

An ulcer which tends to remain superficial, but to spread all over the cornea by a margin of yellowish-white infiltration with an overhanging edge. It depends upon the growth of the pneumococcus between the superficial layers of the cornea. It may result in perforation and loss of the eye, but more frequently damages vision by the irregularity it causes of the corneal surface.

How should serpent ulcer be treated?

By thorough scraping of the edges of the ulcer wherever a point of the characteristic infiltration can be discovered; repeating the scraping as often as any such point appears, and supplementing it by touching the infiltrated portion with tincture of iodin or dilute nitric acid. If the case cannot be seen every day, it is best to destroy all infiltrated tissue with the actual cautery.

What is suppurating ulcer of the cornea?

An ulcer the base and margins of which are of a yellowish-gray from purulent infiltration, and which tends to extend in one or more directions by the breaking down or sloughing of this infiltrated tissue. Its peculiar character and tendency are due to infection by one or more varieties of the pyogenic bacteria, as the streptococcus, staphylococcus, or gonococcus; it may arise either from a simple ulcer, or as a point of infection, or from an abscess; it tends strongly to perforation, and may lead to suppuration of the deeper tissues and functional destruction of the eyeball.

How should suppurating ulcer of the cornea be treated?

All softened tissue should be carefully scraped away with the corneal spud, the operator at the same time pressing out most of the infiltration from the tissue adjoining it. The ulcer is then to be thoroughly washed with a solution of mercuric iodid, trikresol, or formaldehyd, and the scraping and washing repeated daily until the ulcer loses its tendency to suppuration; then treat it as a simple ulcer. The disinfection of the ulcer and removal of dead tissue may also be effectually accomplished by the use of the actual cautery or galvanocautery, applied so as to destroy all the infiltrated sloughing tissue.

What is abscess of the cornea?

A circumscribed collection of pus within the cornea. It tends to increase by the involvement of neighboring tissue until it finds an outlet; it causes a yellowish opacity beneath the surface of the cornea. In rare cases the pus does not find an outlet, but remains to undergo caseation, giving rise to a permanent opacity of the cornea, which may also be a permanent menace of future inflammation and ultimate loss of the eye.

What is the treatment for corneal abscess?

Open it freely. This may require a crucial incision or even the removal of some of the overlying tissue. Then treat it as a suppurating ulcer.

What are onyx and hypopyon?

Onyx is an accumulation of pus between the layers of the cornea, near its lower margin (see 3, Fig. 44). It is opaque, the color of pus, and its upper margin is nearly or quite horizontal; it appears in connection with abscess or suppurating ulcer of the cornea. *Hypopyon* has a similar appearance, but it is a collection of pus at the bottom of the anterior chamber (see 2, Fig. 44). On changing the position of the eye, it is more

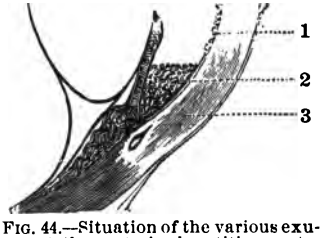

FIG. 44.—Situation of the various exudates: 1, the posterior keratitis punctata; 2, hypopyon; 3, onyx (after Meyer).

apt to be displaced than onyx. Close inspection with the binocular magnifier and the use of oblique illumination will reveal the position of the accumulation. Hypopyon may arise from suppuration of the iris or other deep structures of the eye.

What is interstitial keratitis?

A chronic inflammation of the true substance of the cornea, leading through exudation to opacity of that membrane. The opacity begins near the margin of the cornea, spreads toward the center, and begins to clear up first at the margin. There is a zone of pericorneal hyperemia when the inflammation is at its height, and even when this seems, at first glance, to be absent, it is often very readily provoked by exposure to light or by touching the eye. In most cases the cornea itself becomes vascular, the vessels being quite fine and lying deep in the tissue. From three weeks to as many years are required for the disease to run its course; it is frequently attended by inflammation of the iris and deeper parts of the eye. Its most frequent cause is inherited syphilis, but it may depend on other causes of malnutrition. When due to the former cause it is generally accompanied by the deformity of the teeth known as *Hutchinson teeth* (see Fig. 45). When the

FIG. 45.—Hutchinson teeth; deformity of the upper incisors.

disease has completed its course there is almost always considerable clearing up of the cornea, and in young children a complete restoration may follow great opacity.

What is the treatment of interstitial keratitis?

Locally, irritants are to be avoided, the pupil should be kept well dilated with atropin, and the eye bathed once or twice daily with hot water, until the stage of hyperemia and irritability is past. After this instillations of calomel, or the application of the ointment of the yellow oxid of mercury, may be resorted to to hasten the absorption of the opacity. The constitutional treatment must be such as to quicken

nutritive processes, plenty of exercise, fresh air, good food, preparations of iron, and small or moderate doses of potassium iodid, with small doses of mercuric chlorid. Even when due to syphilis the disease does not yield any more promptly to prolonged active specific treatment, but mercurial inunctions at the outset may be of marked benefit.

What is pannus?

A vascular opacity of the cornea, due to chronic conjunctivitis, trachoma, and affecting mainly the portions of the cornea that come most constantly in contact with the lids. Sometimes it is sharply confined to the portion of the cornea that comes in contact with one lid, as in Fig. 46; in other cases the whole cornea is more or less involved. The opacity lies closely beneath the corneal surface, only exceptionally affecting the deeper layers; and the vessels in it come off from the conjunctival vessels, often including quite large branches. The pannus grows better or worse with the conjunctivitis causing it, and with it tends to continue indefinitely if not treated.

What treatment should be adopted for pannus?

The treatment of the conjunctivitis causing it. When the pannus is general, and the whole cornea supplied with blood-vessels, there is very little danger of the perforation of the cornea by ulceration, and it becomes practicable to treat the conjunctivitis by methods that would at other times be unjustifiable; one of these is to cut short a chronic granular by an acute purulent conjunctivitis, produced either by applying the toxins of pyogenic bacteria or by repeated brushing of the everted lids with an infusion of *jequirity*. When a vascular opacity persists after the cure of the conjunctivitis which caused it, *peritomy* may be resorted to. In this operation an incision is made parallel to the corneal margin, and three to five millimeters from it, the conjunctiva and subconjunctival tissue

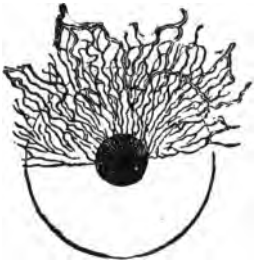

FIG. 46.—Pannus of the upper part of the cornea (after Nettleship).

included between it and the corneal margin completely removed and the exposed sclera thoroughly scarified. The same tissue and vessels may be destroyed by the *galvanocautery*. This is done around so much of the corneal margin as furnishes vessels to the cornea. Another method of treating such cases is with the spud or other similar instrument to scrape away the opacity from the cornea until only transparent tissue is left, repeating the operation if necessary.

What are the different kinds of opacities of the cornea?

A very faint opacity, scarcely perceptible unless looked for by oblique illumination, is called a *nebula*. A spot of perceptible but not complete opacity is spoken of as a *macula*, and one that is densely opaque and usually of a white color is called a *leucoma*. Ulcers of the cornea cause these various opacites according to their depth, leucoma being left by an ulcer that has destroyed most of the thickness of the cornea. When the leucoma is the cicatrix of a perforating ulcer, and has still a portion of the iris embedded in it, it is called an *adherent leucoma*.

What corneal opacities are congenital?

Occasionally minute dots are found scattered through the cornea as a congenital defect. Another form of congenital opacity, affecting the whole cornea, seems due to a sort of intra-uterine, interstitial keratitis. Although so dense as to hide the pupil at birth, it may clear up sufficiently to allow very useful vision.

What is bandlike opacity of the cornea?

A form of opacity that affects eyes that have been lost by previous inflammation; and sometimes, in old people, eyes previously healthy. It consists in a film of calcareous matter deposited just beneath the epithelium in the band of cornea that is habitually exposed to the air by the opening of the lids.

What may be done for corneal opacities?

The period of absorption and resolution after the formation of an inflammatory opacity of the cornea may be prolonged, and rendered more effective in the removal of the opacity, by

the occasional use of mild irritant applications with massage, such as instillations of calomel or the application of the ointment of the yellow oxid of mercury, also by repeated bathing of the eye with hot water.

What operative treatment may be needed?

Where a leucoma hides the pupil while other parts of the cornea are clear, an iridectomy may be done to give a clear pupil. Usually the vision thus obtained will be quite imperfect, and if the patient previously possessed good vision with the other eye, he will not feel the operation to have benefited him much, but if he has been entirely blind, the vision thus conferred will be very satisfactory. Bandlike opacity may be scraped off, and other opacities are sometimes rendered less dense by the operative removal of the opaque tissue. Transplantation of the rabbit's cornea should be done only where the opacity does not involve the whole thickness of the cornea. Tattooing with India-ink renders leucoma less of a deformity; it must be repeated every two or three years to keep the eye looking its best, and it is not free from danger.

What is staphyloma of the cornea?

The bulging of a cicatrix following corneal ulcer. It may occur where the cornea has not been perforated, but only greatly weakened; but mostly it is a cicatrix involving the iris. The incorporation of the iris with the cicatrix causes an increase of the tension of the eyeball, which often leads to the distention of the whole globe, but more especially of the comparatively weak cicatrix. In the process of distention the iris may be more and more drawn into contact with the cornea until it is all involved, the partial staphyloma becoming total. In some cases the prominence of the globe is so great that the lids cannot be closed over it, and the exposure causes a constant inflammation of the part.

What is to be done for staphyloma?

When but partial, some of the cornea remaining clear, an iridectomy should be done if it shows any tendency to increase or there is high tension of the globe. When the bulging of a total staphyloma is excessive the cornea, lens, and ciliary

body may be removed by the operation of *abscission*, or keratectomy; or enucleation of the eyeball or one of the substitutes for enucleation may be done.

What is conical cornea?

By exhausting constitutional disease the cornea may be so softened that without previous thinning by ulceration it yields before the tension of the contents of the globe. When the yielding is mainly at one point the cornea comes to assume a somewhat conoidal shape, and hence the affection is called *conical cornea*. The same appearance may be caused by thickening of the cornea over the region of protrusion.

With moderate projection the cornea remains clear, but becomes hazy if it be excessive. The apex of the cornea always shows a highly myopic refraction, but the sides are less myopic or even hyperopic. These conditions give a peculiar angular form to the light and shadow in the pupil when examined by skiascopy. The condition may continue progressive until the eye is deprived of useful vision, but the distended cornea very rarely ruptures.

What can be done for conical cornea?

When moderate in degree and not progressive, good vision may be obtained by correcting lenses, especially very strong concave cylinders. When the protrusion is very great and increasing, it may be checked by cutting the apex of the cornea or burning it with the galvanocautery; this leaves this part of the cone more or less opaque, but vision may sometimes be improved by doing an iridectomy, so as to give a clear pupil behind the most favorable part of the cornea.

What is keratoglobus?

A globular enlargement of the cornea, which may come to have a diameter one-third greater than normal and to be correspondingly prominent. The anterior chamber is deep, the iris flat, and the pupil small. This condition develops in early life. Correction of the error of refraction is the only treatment indicated.

What is arcus senilis?

A gray arc a little distance within the upper and lower

margins of the cornea, which gradually becomes more dense and extends until it forms a complete circle. It is due to a fatty change in the cornea, is usually seen in old people, but sometimes occurs in childhood; it is of very little practical value as an indication of fatty degeneration in other parts of the body, and does not constitute any serious contraindication to corneal operations.

DISEASES OF THE SCLERA.

What is scleritis or episcleritis?

An inflammation of the sclerotic coat and overlying tissue, showing itself in purplish patches of deep hyperemia, running a very chronic course, like inflammations in other dense fibrous tissues. It may end in complete resolution, though sometimes not until the softening of the coat has led to a local bulging or staphyloma. Sometimes as one patch gets well another is affected, so that the disease is continued for months or years. It is dependent on constitutional conditions, especially rheumatism.

What is the treatment for scleritis?

Avoid irritant applications; bathe the eye with hot water and instil atropin solution; touching the affected area with the actual cautery, or gentle massage through the closed lids, is sometimes beneficial. General treatment is even more important. Syphilis, gout, or rheumatism should be carefully attended to. Diet and habits of living must be regulated; and it may be worth while to try change of climate and the use of mineral waters.

How does staphyloma of the sclera occur?

Through weakness of the sclerotic coat by traumatism, deep inflammation, or gumma of the ciliary body; or through prolonged increase of the intra-ocular pressure. It is divided, according to location, into ciliary, equatorial, and posterior staphyloma. The former are seen as elevations and thinnings of the sclera. The latter is studied with the ophthalmoscope; it accompanies myopia. Removal of the cause is the only treatment.

DISEASES OF THE IRIS.

What are the evidences of hyperemia of the iris?

A zone of pericorneal redness, just like that seen in keratitis (see page 107), contraction and sluggishness of the pupil, and thickening and discoloration of the iris itself. The discoloration is scarcely noticeable in certain brown eyes, but in eyes normally gray or blue it causes a greenish hue that is quite different from the normal appearance. Change of color in the iris may also be caused by discoloration in the cornea or aqueous humor. Very pronounced hyperemia is always to be regarded as indicating actual inflammation of the iris, but sometimes iritis occurs without hyperemia that has attracted the attention of the patient.

What are the subjective symptoms of iritis?

Pain, of an aching or neuralgic character, located in and about the eye, often referred to the brow or side of the nose, is generally present and severe; it is liable to exacerbations, especially at night, in which it is but partially relieved by morphin. In some cases pain is quite absent. Tenderness of the eyeball on pressure may be entirely absent, and when present it is generally to be referred to an accompanying cyclitis. The eyes are irritable; the discomfort or pain is increased by attempts to use them, or on exposure to light. Vision is usually imperfect from clouding of the media by exudate.

What are the effects of exudation in iritis?

The iris is thickened and its normal retraction toward the periphery, which causes the normal dilatation of the pupil, is prevented. This may be the case for all parts of the iris equally, or it may be confined to certain segments of the iris, when the thickening of these parts is more noticeable and the dilatation of the pupil irregular. The common cause of irregularities of the pupil is the adhesion of some part of the iris to the lens capsule. When the pupil is contracted, the iris near its margin rests upon the capsule of the lens. If, in this position, any plastic exudate is thrown out upon its posterior surface, it will be glued fast to the lens. At first the

wide dilatation of the pupil by atropin is able to tear loose these adhesions and liberate the iris; later it may stretch them and thus secure some additional freedom of motion, but after a time they become organized, and mydriatics have little power over them.

How would you look for irregularity of the pupil?

Commonly at first the pupillary margin of the iris becomes adherent at scattered points only, at which the iris remains bound down while other parts of the pupil dilate, and thus the pupil becomes irregular. This irregularity is only shown or best shown under conditions that conduce to the dilatation of the pupil. In strong light, looking at a near object, the pupil may be perfectly regular, when by the use of a mydriatic, or even in a dim light or by relaxing the convergence, it is shown to be very irregular. In doubtful cases it is well to dilate the pupil with cocain or euphthalmin, to make certain the diagnosis, before employing one of the stronger, more persistent mydriatics. Fig. 47 represents the pupil as irregularly dilated by a mydriatic in iritis.

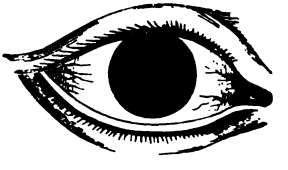

FIG. 47.—Adhesions of iris to lens capsule in iritis, shown by dilating the pupil.

What is exclusion of the pupil?

The binding down of the whole margin of the iris to the lens, so that there is no communication between the space back of the iris and the anterior chamber, the pupil itself, however, remaining clear.

What is occlusion of the pupil?

The pupil itself is filled with lymph, preventing any useful vision; in addition to this the whole posterior surface of the iris may be fastened to the lens by the great quantity of plastic exudate.

What is keratitis punctata posterior?

An opacity of the cornea produced by dots of exudate on its posterior surface (see Fig. 44). These dots of opacity are

usually distributed over a triangular area, as shown in Fig. 48; they are sometimes very fine, but may be so abundant as to run together, forming masses, especially at the lower part of the cornea. Commonly they entirely disappear within a few weeks or months after recovery from the iritis that causes them.

FIG. 48.—Deposit on posterior surface of the cornea in iritis.

What is the general course of iritis?

It begins with moderate discomfort, excessive lacrimation, and redness of the eye. These symptoms increase from day to day, often for a period of two or three weeks; the redness at first may be quite as much conjunctival as pericorneal; the pain gradually assumes the character of an ache, which grows more severe and comes to be referred to the brow and cheek as well as to the eye; the period of severe pain may last for several days or even weeks; it terminates by gradual decrease, or ceases suddenly after the trial of some remedial measure or a good night's rest. After the inflammation has subsided, the exudate diminishes, and, where adhesions have been prevented, it may disappear entirely. The redness subsides gradually, and after the eye has become white it may be reddened by slight irritation.

What is serous iritis?

Inflammation of the iris in which the serous element in the exudate so preponderates over the plastic that it does not accumulate in the iris or upon its surface sufficiently to cause any adhesion to the lens capsule; but it always causes keratitis punctata. Cases of iritis, in the main serous, often cause one or two slight adhesions. Serous iritis is, at least in many cases, a cyclitis, with but little real involvement of the iris.

What is plastic iritis?

The most common form; usually attended with pain and redness around the cornea, and running an acute course in a few weeks, with or without adhesions, according to the violence of the attack and the efficiency of the treatment. Some-

times it is more chronic, lasting many months, with repeated exacerbations, or it may be comparatively free from pain and redness, so that firm adhesions occur very insidiously. Sometimes the whole anterior chamber is filled with plastic exudate; such a case is called one of *spongy iritis*.

What are parenchymatous and purulent iritis?

The former is characterized by great swelling of the iris itself, and is apt to leave some permanent changes in parts of its tissue. Purulent iritis is often included under this head; it is apt to occur with purulent inflammation of other parts of the eye as purulent keratitis. It may cause hypopyon, or the pus may be carried off without accumulating in the anterior chamber.

What is insidious iritis or uveitis?

A form characterized by slight redness and pain, and absence of marked changes in the appearance of the iris. But the attacks tend to recur, causing a general adhesion of the posterior layer of the iris to the lens capsule. It usually occurs in anemic, poorly nourished persons, who show signs of auto-intoxication. If not checked it is likely to cause blindness of the eye affected. Improved diet, and tonics with outdoor life are indicated.

What is syphilitic iritis?

An attack occurring, as it very frequently does, as one of the secondary manifestations of syphilis. Generally both eyes are affected, though to a different extent, while in iritis from other causes but one eye may suffer. Syphilitic iritis runs a slow course; though it often begins in the serous form it later becomes plastic. The adhesions of the iris to the lens capsule are comparatively broad and unyielding. Small papules or condylomata are usually to be seen near the margin of the pupil. These are quite distinct from gummata. They break down, sometimes giving rise to visible débris in the anterior chamber.

What is gumma of the iris?

A rounded growth or swelling, appearing in the iris during the tertiary stage of syphilis, and always attended with iriti

Two or more such swellings may be present in the same iris, and both eyes are likely to be affected. Under active anti-syphilitic treatment it commonly disappears, leaving a distinct cicatrix or an atrophied patch in the iris.

What are the special characters of rheumatic and gouty iritis?

The former may accompany an outbreak of acute rheumatism or may be caused by cold. The pain and hyperemia are severe. Adhesions form early, but are narrow and rather easily broken by a mydriatic. Only one eye may be affected, but attacks are liable to recur. It is likely to respond promptly to the free use of salicylates. Gouty iritis in general resembles rheumatic, but the attacks are less severe and even more liable to recur. They may be insidious.

What are the other important varieties of iritis?

Gonorrheal iritis may be extremely violent, with great swelling of the iris and abundant exudate, but it is likely to end in rather rapid and comparatively complete recovery. Sometimes it runs a chronic course, relapsing with every recurrence of the urethral discharge.

Diabetic iritis is usually quite plastic, but may be purulent in character. It also ends in comparatively good recovery.

Traumatic iritis may arise from direct injury of the iris, or from bruise or wound of the eyeball, that appears to leave the iris unharmed.

Ophthalmia nodosa (see page 101) may involve the iris.

Tubercular iritis may occur without evidence of tubercular deposits in other organs.

Iritis often complicates keratitis.

What diseases must be distinguished from iritis?

Glaucoma, in which the pupil is usually dilated and the tension of the eyeball perceptibly increased, and in which a mydriatic might do harm. *Keratitis*, in which the pupil is contracted and the pericorneal vessels injected, but in which the pupil dilates well under one of the weaker mydriatics, and the corneal lesion may usually be discovered by careful examination. *Conjunctivitis*, in which the redness is due to the enlargement of the conjunctival vessels and the pupil

reacts freely, and in which the use of atropin would do no good, but would cause unnecessary annoyance. The pain of iritis has sometimes been ascribed to *neuralgia*, the redness and lacrimation being regarded as secondary to the pain.

How should mydriatics be used for iritis?

Place the pupil under the influence of a strong mydriatic, as atropin, as soon as possible. This will not be especially difficult to do in serous iritis, but in severe plastic, or parenchymatous iritis, the drug must be used vigorously. A drop of a strong solution or a little solid atropin sulphate should be placed above the cornea every five minutes until the pupil is dilated. To avoid any danger of atropin-poisoning, the lacrimal puncta should be kept everted during this time by pressing the finger against the side of the nose in such a way as to draw on the skin of the lids near the inner canthus. The keeping of the solution from reaching the mucous surfaces of the nose and throat is made more certain by holding in contact with the puncta a bit of absorbent cotton. After the pupil is once dilated it must be kept so by instillations of the mydriatic, repeated every few hours. As the eye gets better the drug may be used less frequently, but it should be continued at least twice a day until the eye has been for some days quite free from pain or redness.

What other local treatment does iritis require?

Bathe the eye with very hot water for a few minutes at a time. This may be done just before the instillation of the atropin. This will be found one of the best means to relieve pain. But the bathing must not be used very long at a time or very frequently repeated. Dionin, in 10 per cent. solution, or powder, placed in the eye once or twice in twenty-four hours will often relieve pain and secure wide dilatation of the pupil. The eye should be shielded from bright light. The wearing of dark glasses is usually sufficient after the violence of the inflammatory process has passed its maximum. A bandage, that might act as a poultice, is always to be avoided. Confinement to a *dark room* is so depressing to the patient's general condition that it should generally be avoided, and never continued for more than a day or two.

When should local bloodletting be resorted to?

When the hyperemia is active and the pain severe. It will often afford more complete relief from pain than will any other measure that can be resorted to. The relief from pain is a good guide to the amount of blood to be taken, and the recurrence of pain is the best indication for a repetition of the bloodletting. The blood is usually taken from the temple, as close to the edge of the orbit as is convenient. Either natural leeches or the artificial leech may be used.

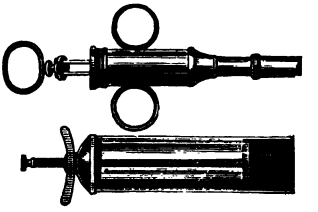

FIG. 49.—Artificial leech, knife and cylinder for drawing blood.

What is the artificial leech?

A small rotary knife (Fig. 49) that can be set to cut to any desired depth; and a cylinder with a piston to exhaust the air from it. To use the leech, the skin is carefully cleansed, and the cut made where the surface is sufficiently flat to permit the application of the end of the cylinder. This is then applied to the moistened skin and rapidly screwed up to create a vacuum. Generally, one-half ounce or more of blood may be taken at one application of the cylinder. When the flow has nearly ceased, the blood may be emptied from the cylinder, which may be reapplied as often as may be necessary to accomplish the desired effect. The leech-wound should be washed and covered with collodion or adhesive plaster.

What is the general treatment for iritis?

In the early stage of acute iritis, complete rest, with the head elevated, is beneficial. At the same time a mild purge, action as may be had from the use of calomel, is l exerting a beneficial influence on the

plastic exudate, whatever the cause of the iritis. If syphilis, rheumatism, or gout be actually present, it should be actively treated. Many of the worst cases of iritis occur in anemic and cachectic patients, to whom good food, avoidance of exposure, and the use of tincture of iron are a very important part of the treatment. Quinin, in moderate doses, is beneficial in nearly all cases.

What are the common sequels of iritis?

Adhesion of the iris to the lens capsule, called *posterior synechia.* This may be partial, causing the iris to be dragged upon in certain directions when the pupil should dilate, and in some cases rendering the iris unhealthy and liable to new attacks of inflammation; or it may be complete, checking the normal flow of aqueous through the pupil, causing it to push the iris forward, ballooning the iris (see Fig. 50); or even, when the lens and iris are firmly united over a large surface, pressing the lens forward, and causing a secondary glaucoma. In some cases iritis leaves a myopia, usually temporary. Occlusion of the pupil when it occurs is to some extent permanent.

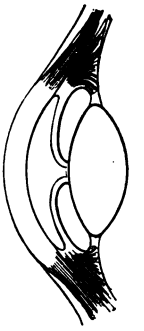

FIG. 50.—Ballooning of iris (after Nettleship).

How are the sequels of iritis to be treated?

Mainly by prevention, by active intelligent treatment in the early stages of the disease. If this has not been successful, something may be accomplished by the division of adhesions, when there seems to be a tendency to repetitions of the first attack. Iridectomy may be done if the adhesions have been extensive, and is urgently indicated for exclusion of the pupil and bulging of the iris. Occlusion may require iridectomy or even extraction of the lens. Myopia may need glasses for its correction, which will have to be changed or discarded if the myopia subsequently diminishes.

Describe the operation of iridectomy.

It is the excision of a portion of the iris. To do it an in-

cision is made in the margin of the cornea nearest the part of the iris to be removed, then, if the iris is not washed out by the escape of aqueous, a pair of fine iris-forceps or an iris-hook is introduced and the part of the iris to be excised is pulled outside the corneal incision and cut off. Then the stump is carefully returned within the anterior chamber, permitting none of it to remain in the corneal incision, and the eye kept closed until the corneal incision has united.

What are the principal varieties of iridectomy?

Optical iridectomy is done when the natural pupil is so obstructed by corneal opacity or exudate in the pupil as to prevent useful vision (see Fig. 51). The aim should be to make the

FIG. 51.—Artificial pupil, after occlusion of the natural pupil.

artificial pupil as small as it can be made without danger of its being closed again by inflammatory reaction. It is better to so place the opening that the margin of the lid shall not come before it, because the tears along the lid margin cause diffusion of light that interferes greatly with distinctness of vision. But if the operation is done for corneal opacity, we are often compelled to place it behind the clearest portion of the cornea that will be exposed when the eye is open. Iridectomy to remove a foreign body or new growth in the iris will have its position and extent determined by the location and extent of the part of the iris involved. Iridectomy for glaucoma will be considered in connection with the treatment of that disease.

What other operations are done on the iris?

Iridotomy, incision of the iris, when it is desired to make an artificial pupil, and the iris is held so much on the stretch that a simple incision will gap sufficiently without the removal of any tissue. This operation is especially suitable for cases in which the lens has been lost by injury or

through cataract extraction, and the iris drawn up toward the scar by inflammatory contraction. It may be done with a knife or with the de Wecker forceps-scissors, which have one sharp point for penetrating the iris. If on incising the iris it does not retract enough to give a good pupil, a piece must be cut out with scissors as indicated in Fig. 52. *Iridodesis*, draw-

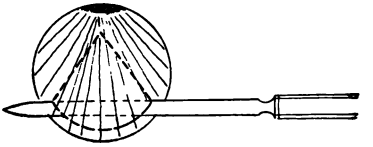

FIG. 52.—Kuhnt's method of removing triangle of iris and capsule.

ing the pupil into a new shape and position, is accomplished by making a small incision in the cornea, and drawing a part of the iris, including some of the pupillary border, into it, and fixing it and strangulating it there with a ligature.

What new growths appear in the iris?

Cysts form in it, varying in size from one that is barely perceptible to one that fills the anterior chamber and causes glaucoma. These arise from traumatism, and sometimes include epithelium or a part of an eyelash that has been carried into the iris by some wound penetrating the cornea. They require removal. Benign *granulomata* appear as small, light tumors. *Sarcoma* is occasionally primary in the iris. *Tubercles* occur as small, whitish masses; or the tuberculous deposit may take the form of one or more large masses, *tubercular granuloma*. The presence of tubercle in the iris is always attended with inflammation. The early removal of the part of the iris containing such growths may prevent general infection.

What is persistent pupillary membrane?

The remains of the membrane that entirely closes the pupil during early fetal life. Usually it consists of but one or a few threads that are attached to the anterior surface of the iris some distance from the pupillary margin, and which

float freely in the aqueous humor, without hindering the mobility of the pupil or the transmission of light.

What is coloboma of the iris?

An absence of a part of the iris. The term is sometimes applied to the space left by iridectomy, but is generally, unless otherwise stated, to be understood as a congenital deficiency, usually extending downward from the pupil. If complete, extending to the ciliary margin of the iris, it reveals the border of the lens and the ciliary processes, unless these, too, be partly wanting.

What are the other congenital anomalies of the iris?

In a great many eyes the shape of the pupil is not exactly circular, and sometimes the irregularity of shape is considerable. Often the pupil of one eye is slightly larger than the other. Peculiarities in the pigmentation of the iris are often seen, and sometimes the iris of one eye differs in color from the other. This is called *heterochromia*, or *heterophthalmos*. When one eye is a decided brown and the other a uniform blue or gray, indicating absence of pigment, the latter may have been the seat of previous disease, or it is liable to be affected by cataract, although the dark eye remains normal. *Corectopia* means that the pupil is not situated in its usual position, but is more or less eccentric. *Polycoria* is the term used to indicate that one or more supernumerary pupils exist, separated from the central pupil and from each other by bridges of iris tissue. *Irideremia*, or *aniridia*, is the condition of complete absence of the iris. In it the whole area of the cornea has the appearance of the pupil. In *albinism* the iris frequently has a pink appearance, due to the shining of the fundus reflex through the stroma, devoid of pigment.

DISORDERS OF THE MOVEMENTS OF THE PUPIL.

What is the normal size of the pupil?

From one to eight millimeters in diameter. Except in extreme cases it is impossible to be certain that the size of the pupil is abnormal, unless we know previously the size of that particular person's normal pupil. In some cases it is difficult to get the pupil to contract below three millimeters, in

others this is the extreme limit of dilatation. These differences of size depend on differences in motility and on differences in the original structure of the iris. The pupil is generally large in children and small in elderly people.

What is the movement of the pupil associated with convergence?

It contracts when the eyes are converged more strongly, and dilates when the visual axes are allowed to become less convergent or parallel. The absence of any such movement, with the accommodation and convergence of the eyes, generally indicates paralysis of the third or oculomotor nerve, or of the center for this contraction of the pupil, or posterior synechia. This movement is tested by having the gaze fixed alternately on a distant and a near object, both in a line with the eye, so that the illumination will not be changed.

What is the reaction of the pupil to light?

It contracts as the light entering the eye grows brighter, and dilates as the light becomes more feeble. It reacts most to the light which falls on the most sensitive part of the retina, the macula. The pupil of one eye reacts to the light which falls on the retina of the other eye, as well as to that which falls on its own. The extent of reaction varies greatly in different individuals, but is generally greater in children and less in old people.

How do you test this reaction?

When in position for the ophthalmoscopic examination in a darkened room, hold the mirror a foot or more from the eye to be tested, and, looking through the aperture at the pupil, alternately throw the light into the eye and then elsewhere, leaving it in comparative darkness. While the eye is in darkness the pupil becomes dilated, and for an instant after the light is thrown upon it remains in this dilated condition, but very quickly thereafter contracts, an appreciable time being required for the reaction. The eye tested should be kept constantly fixed upon one point, usually the aperture in the mirror used. When, in blindness, the pupil still reacts well to light, it indicates that the lesion is in the occipital lobe; when the reaction is lost, it points to the centers at the

base of the brain, the optic tract, nerve or retina, as the seat of disease. Blindness must be absolute to prevent reaction.

What is the Argyll-Robertson pupil?

The condition in which the pupil does not react to light, although vision shows the visual tract to be unimpaired, and the contraction of the pupil, with convergence, proves the motor apparatus concerned to be healthy. The lesion is supposed to affect the fibers which connect the sensory optic tract and the nucleus of the oculomotor nerve, which presides over the contraction of the pupil. This loss of reaction to light may affect one or both eyes. It is a symptom very significant of locomotor ataxia and general paralysis of the insane. It must be carefully distinguished from fixity of the pupil due to iritic adhesions or rigidity of the iris.

What is the hemianopic reaction of the pupil?

The reaction of the pupil when in a case of hemianopsia the light is thrown on the blind half of the retina. The absence of this reaction is the complete failure of the pupil to contract when light is thrown on the blind half of the retina. In testing for it, care must be taken to concentrate the light on the blind half of the retina, while leaving the seeing half in darkness.

What are mydriasis and myosis, and their significance?

Mydriasis is a persistent dilatation of the pupil; *myosis* its persistent contraction. They occur in so many different conditions as to have no great separate significance. When monolateral, or markedly greater on one side than the other, they point to a focal lesion rather than to the action of a general poison, and hence may be of great importance in cases of coma. But in general the size of the pupil is of much less significance than its reactions under the tests described above.

What is hippus?

Alternate contraction and dilatation of the pupil. An exaggeration of the normal change, which occurs from every change of light or tension of accommodation and convergence.

DISEASES OF THE CILIARY BODY AND CHOROID.

What are the symptoms of inflammation of the ciliary body, or cyclitis?

Pain and tenderness on pressure, and redness of the circumcorneal region similar to those encountered in iritis, but without any inflammation of the cornea or iris to account for them. The pain of simple cyclitis is generally less than that of iritis. Cyclitis rarely occurs except in connection with iritis or choroiditis. It may give rise to disorders of the accommodation, or apparent change of refraction. True cyclitis is always attended with some haziness or more decided opacity of the vitreous, and consequent impairment of vision. It is probably always present in connection with iritis when this is accompanied by notable changes in the tension of the eyeball, or haziness of the anterior portion of the vitreous humor.

What is the treatment for cyclitis?

In the main, the same as that for iritis. But mydriatics must be used with more caution. In some cases they seem essential to the best recovery. In others they may be even harmful. If the pupil dilates freely under their influence, showing little involvement of the iris, and correspondingly little danger of permanent damage by iritic adhesions, it may be well to suspend the use of the mydriatic. If the tension of the eyeball becomes noticeably elevated, it should be stopped at once.

What are the subjective symptoms of choroiditis?

The pain is of an aching character if the inflammation does not involve any other structure, is not severe, and often it is quite absent. During the acute stage there are subjective flashes of light. There is impairment of vision, though this may be quite insignificant as compared with the changes visible in the choroid, and may not be noticed if it does not involve the region of the fixation-point. Spots or clouds are noticed before the eyes. These may be scotomata due to patches of inflammation, in which case they are fixed, or they may be due to opacities in the vitreous, and float about with every movement of the eye.

What is the external appearance of the eyeball in choroiditis?

It may be quite normal; but if the inflammation is quite acute, there will be enlargement of the deep vessels that run straight forward in and over the sclera, causing a dull redness of the whole globe, and in very acute cases there is often a good deal of edema of the ocular conjunctiva.

What is plastic choroiditis?

A series of slow inflammatory changes in the choroid, beginning with hyperemia and a moderate amount of exudation, and ending usually in a more or less complete atrophy of the part of the choroid involved. It runs a course of months or years, and is apt to begin in one spot and slowly spread to adjoining regions. This definition does not include cases often spoken of as plastic, and in which great quantities of fibrinous exudate are poured out, but accompanied with some formation of pus.

What are the ophthalmoscopic appearances of plastic choroiditis?

At first a blurred appearance due to swelling, which hides the details of the choroid normally visible. This may be a darker red than the normal fundus, from hyperemia or hemorrhage, or of a light yellowish color, from serous or plastic exudation. Later, changes appear in the pigment layer. It may be simply absorbed, or, as commonly happens, it is absorbed in some places and at others is heaped up into masses of a brown or black color that give a very striking appearance.

What is disseminated choroiditis?

Plastic choroiditis affecting numerous patches of the choroid, separated by portions that are comparatively healthy. This is the most common form, though the number of separate patches involved is often small (Fig. 53).

What is central choroiditis?

Plastic choroiditis confined to a single patch in the region of the macula. The retina almost always participates actively in the process, and serious impairment of vision, if not com-

plete central scotoma, results. One form of this, occurring in old people, has been called senile choroiditis, another form is congenital.

What are the appearances of choroidal atrophy?

The process, commencing with the removal of pigment, leaves the choroidal vessels more distinctly visible than nor-

FIG. 53.—Disseminated choroiditis and choroidal atrophy (after Noyes).

mal. Then, with the atrophy of other tissue-elements, the smaller vessels disappear, leaving only some of the largest vessels with scattered masses of brown or black pigment. Finally, the larger vessels disappear entirely, and over considerable areas nothing is to be seen but the glaring white sclera with which is fused the connective-tissue remains of the choroid. Frequently different parts of the same eye exhibit all the different stages of the process simultaneously. After it has run its course the results of the inflammation continue visible in the fundus throughout life. There are very frequently floating opacities in the vitreous humor.

What is sclerotico-choroiditis posterior?

A plastic choroiditis and subsequent atrophy (usually located or beginning at the temporal margin of the optic disk) in which the sclera may become so far implicated in the process that it softens and gives way before the outward pressure of the ocular contents, and bulges, forming a *posterior staphyloma* (Fig. 54). The local process is commonly accom-

FIG. 54.—Posterior staphyloma (after Liebreich).

panied by general distention of the globe and consequent myopia. The patch of atrophy produced is at first crescentic, and is often called a *myopic crescent*. As it increases in size it becomes more irregular in shape, with a tendency to a triangular form, and is sometimes called a *conus*. This form often appears as part of a disseminated choroiditis.

What are the causes of plastic choroiditis?

Constitutional disease or dyscrasia, as syphilis, or the impaired nutrition following the specific fevers; and the habitual congestion of the choroid produced by excessive or improper use of the eyes. The appearances of *syphilitic choroiditis* are not pathognomonic, but it commonly presents numerous small, rounded patches of diseased choroid and round pigment blotches. Posterior staphyloma begins mostly in childhood, disseminated choroiditis is common among elderly people.

How should plastic choroiditis be treated?

The eyes should have rest, at least until all acute swelling and hyperemia are over. This may embrace the keeping them under the influence of a mydriatic, with the use of dark glasses and careful avoidance of bright lights and sudden changes of illumination. The complete correction of any error of refraction, and when use of the eyes is resumed, care that it shall be under the best conditions of illumination and posture, are matters of great importance. The constitutional condition must also receive appropriate treatment.

What is purulent choroiditis?

An inflammation of the choroid attended with the formation of plastic exudate and pus, always acute in its onset, generally attended with redness and edema outside the sclera, and commonly causing the loss of sight in the eye affected. Usually the whole choroid is involved, and often all other parts of the globe, constituting the case one of *panophthalmitis.* From the outset the vitreous is so hazy that no view of the fundus can be obtained, and soon even the red reflex is lost. Hypopyon may appear.

How may purulent choroiditis terminate?

Not rarely the eyeball bursts and the pus escapes exteriorly. In other cases the eyeball becomes atrophied or shrunken, and every part of it the seat of degenerative change; and the tension of the globe permanently lowered. This condition is known as *phthisis bulbi.* Or without much alteration of the front of the eye the vitreous may remain filled with pus. This gives a yellowish reflex from behind the lens, resembling that seen in glioma of the retina, and hence called *pseudoglioma.* The diagnosis between the two conditions is made largely by the history of previous inflammation, and the diminished tension of the eyeball in this condition; while in true glioma the tension is likely to be normal or even elevated, and the history points to blindness and the altered appearance of the pupil coming before any inflammatory symptoms. In a few cases resolution and partial restoration of function may occur.

What are the causes and treatment of purulent choroiditis?

Penetrating wounds of the globe, with or without the lodgement of a foreign body, including operative wounds with purulent infection, are the most common cause. But cases result from metastasis, erysipelas, and from other acute febrile diseases, especially cerebrospinal meningitis. In the majority of cases all that can be done is to relieve pain by hot applications, employ general antiphlogistic regimen, and as soon as it is evident that the suppuration is becoming general, open the eye freely to give vent to the pus. If, however, the case is mild, an effort may be made to save some vision, or at least the external appearance of the eye. If the eye is believed to contain a foreign body, it is best to enucleate at once.

When does ossification of the choroid occur?

When an eyeball has long been sightless and the seat of degenerative changes. The whole choroid may be replaced by a shell of bone, but more frequently the change is confined to limited portions of the choroid, which may feel hard, while in other parts the lessened resistance of the shrunken eyeball is encountered. Ossification is liable to cause sympathetic irritation.

What is the course of sarcoma of the choroid?

It commences with a tumor visible with the ophthalmoscope, causing an elevation of the retina, but it is not noticed by the patient until it causes opacity of the vitreous or extensive detachment of the retina. After this the intra-ocular tension increases, the opposite of what occurs in detached retina from other causes, and therefore very significant of an intra-ocular growth. Later, the sclera or cornea is perforated, and the neighboring tissues involved.

How should sarcoma of the eyeball be treated?

Before perforation of the eyeball has occurred, it should be promptly enucleated; after perforation the whole contents of the orbit should be removed.

What is the appearance of tubercles in the choroid?

That of small, rounded, slightly elevated spots of light yel-

lowish color, surrounded by normal choroid, and located in the posterior portion of the globe. These commonly appear late in acute general tuberculosis. Sometimes the disease seems to be primary in the choroid, giving rise to a single large mass, resembling sarcoma in appearance. For this the eyeball should be enucleated to prevent the tuberculosis from becoming general.

What other growths occur in the choroid?

Carcinoma is usually secondary to cancer of the breast, and is likely to affect both eyes. Adenoma, angioma, and enchondroma have, in rare cases, been met with.

What is coloboma of the choroid?

A patch in which there is a congenital absence of some or all the tissues of the choroid. Usually it is situated below the optic disk, sometimes starting from it, sometimes from farther forward, and extending anteriorly. But it may be only a limited patch in some other part of the fundus.

What is albinism?

A congenital absence of pigment from all parts of the eye, usually accompanying a similar absence of pigment from the skin and hair of all parts of the body. In it the choroidal vessels are all visible, the fundus reflex is unusually bright, and is visible through the structure of the iris, giving it a pink hue.

SYMPATHETIC OPHTHALMIA.

What is sympathetic irritation?

When one eye has been functionally destroyed and its tissues are the seat of extensive degenerative changes, particularly if the lost globe contain a foreign body, or a calcareous lens, or an ossified choroid, it is liable to set up in the other eye, probably through the agency of the ciliary nerves, a neurosis characterized by extreme irritability, pain, and hyperemia, greatly increased by attempts to use the eye. This is called sympathetic irritation. It generally arises a long time after the loss of the first eye, increases gradually, and tends to continue indefinitely until the removal of the

exciting cause. In some cases the presence of a blind and degenerated eyeball appears to influence unfavorably the other eye, without giving rise to the irritation, pain, and photophobia which usually attend sympathetic disease. Yet the removal of the blind eye improves to a marked extent the condition of its fellow.

What is the treatment for sympathetic irritation?

Removal of the exciting cause in the blind and degenerated eyeball. Without this no other treatment will give relief; but with enucleation of the exciting eye, the other becomes normal in a few hours or days without other treatment. An eye, regarded for years as entirely blind of sympathetic irritation, has been demonstrated to possess normal vision within a few hours after the excision of the eye that was exciting the sympathetic irritation. In most cases evisceration will answer the purpose equally well, and even abscission may be all that is required to remove the source of irritation.

What is the operation of abscission or keratectomy?

The removal of the cornea and iris, with such other portions of the globe as may be necessary to insure smooth closure of the scleral opening. It is commonly done on eyes that have suffered from sloughing or perforation of the cornea, followed by staphyloma. With a cataract-knife the eyeball is transfixed from side to side, and the knife made to cut upward or downward, forming a flap, which includes one-half of the staphyloma. The excision of the whole staphyloma is then completed with scissors in such a way that the whole anterior segment of the eyeball is removed. The lens, if not previously lost, comes away with the staphyloma, and most of the ciliary body is also removed with it. The lips of the sclera are to be trimmed into shape, and all masses of thickened degenerated tissue removed from them. They are then brought together by three or more interrupted sutures, and the eye dressed and treated as for a severe wound of the sclera.

What is sympathetic inflammation of the eye?

An inflammation which may involve all the tissues of the

eye, but in which a plastic or purulent iridocyclitis and choroiditis predominates, which comes on as the result of previous similar inflammation in the other eye, due generally to a penetrating wound, and especially liable to result from the retention of a foreign body. The eye primarily involved is called the "exciting eye," the other the "sympathizing eye."

What are the causes and pathology of sympathetic ophthalmia?

Sympathetic irritation has clearly the character of a neurosis. The symptoms in the sympathizing eye must be purely reflex to disappear so quickly after the removal of the exciting cause. Of the causes that lead to sympathetic ophthalmitis, the injury to the exciting eye is the only one that is well understood. Yet injury to one eye does not cause sympathetic inflammation in the other until the injured eye has itself become the seat of an iridocyclitis. Eyes lost through violent suppurative inflammation are not likely to cause sympathetic inflammation, and injured eyes that recover without plastic inflammation of the ciliary body and iris do not cause sympathetic disease.

To account for the transmission of inflammation from one eye to the other, the following theories have been advanced: 1. That the transmission occurs through the ciliary nerves, in the form of nerve-impulses such as seem to cause sympathetic irritation. 2. A direct extension of inflammation along the optic-nerve, chiasm, and optic nerve of the sympathizing eye. 3. The migration of microbes in the optic-nerve sheaths from a focus of infection in the exciting eye. 4. The migration of germs from one eye to the other, through the general circulation, the sympathizing eye offering peculiarly favorable conditions for their development. 5. The injury of the sympathizing eye by toxins reaching it from the exciting eye along the optic-nerve sheaths or through the general circulation.

At what time is sympathetic inflammation likely to occur?

At any time from two or three weeks after the injury of the exciting eye until six or eight weeks after its removal.

But few cases occur during the first month, or after the first two years, and it is not likely to occur unless there be at the time, or has recently been, some evidence of inflammation present in the exciting eye.

What are the symptoms of sympathetic ophthalmitis?

The earliest resemble those of sympathetic irritation, which has sometimes been regarded as a premonitory stage of the inflammation. There is photophobia, lacrimation, failure of power of accommodation, and discomfort on attempting to use the eye. At this stage the ophthalmoscope may show a distinct inflammation of the optic nerve and retina. The symptoms of iritis supervene, at first serous, then plastic. Then the vitreous becomes cloudy, from choroidal inflammation; vision is greatly impaired, and finally lost in the great majority of cases. The disease runs quite a variable course. Sometimes the sight is lost very quickly. Usually there are partial recoveries and new exacerabations; and often it requires years for the eye to become quiet.

What is the prognosis for sympathetic inflammation?

If the inflammation in the sympathizing eye is really started, probably complete or almost complete loss of sight, although there are numerous cases of complete, or almost complete recovery, most of them after early removal of the exciting eye.

How is sympathetic inflammation of the eye to be prevented?

By such treatment of an injured eye as will prevent the chronic inflammation of the iris and ciliary body, attended with diminished tension of the eyeball that causes an eye to excite sympathetic inflammation in its fellow. Failing to accomplish this, the eye which has become the seat of the dangerous inflammation should be subjected to enucleation or one of the substitutes for enucleation. Enucleation is probably a little more certain as a preventive, and it is followed by quicker healing and less pain. Evisceration, with implantation of an artificial vitreous, may leave a rather better stump, and sometimes a patient will consent to it when he would not allow complete removal of the eye.

In what cases should an injured eye be removed?

1. When it is hopelessly blind and is believed to contain a foreign body, it should always be removed. 2. When it is seriously damaged and is believed to contain a foreign body, and the patient is unable to remain where he can be under frequent observation and at any time resort to surgical aid. 3. When functionally lost by iridocyclitis, and the patient cannot remain under observation, although no foreign body may be present. 4. When an eye with greatly damaged vision remains persistently inflamed, or is subject to recurring attacks of inflammation. 5. When the sight has been lost and sympathetic irritation or inflammation begins in the other eye. If the sight of the exciting eye is still useful, and inflammation is begun in the other, the first eye should be retained, as it may in the end be much the better of the two. An eye should not be removed unnecessarily, as even a disfigured stump is less care and inconvenience than an artificial eye.

How is the operation of enucleation performed?

If the eye is free from inflammation, it may be done under cocain with little more pain than an ordinary tenotomy; but

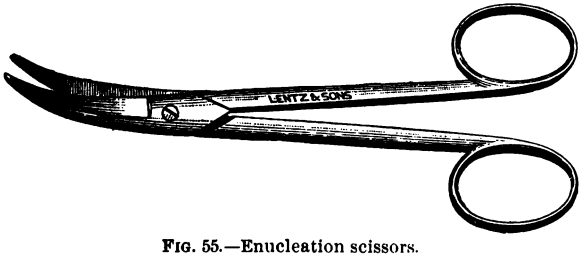

FIG. 55.—Enucleation scissors.

if there is hyperemia of the tissues to be cut, ether should be given to full anesthesia. Having the eyelids kept apart by an assistant or with a speculum (see Fig. 23), take in one hand a pair of scissors with fine blunt points, and in the other hand a pair of fixation-forceps; fix the eye and divide the ocular conjunctiva all around the cornea. Seize firmly the insertion

of the internal or external rectus muscle, and, drawing upon it, divide the tendon just back of where it is held by the forceps. Then pass one blade of the scissors under the tendon of the superior rectus and divide it, with the tissue about it, close to the globe; in the same way divide the inferior and the other lateral rectus. Then pulling the eyeball well forward, pass the enucleation scissors, which should be strong and curved on the flat (see Fig. 55), back of the eyeball, and divide the optic nerve and adjoining tissue. The globe may now be dislocated forward, and the oblique muscles and any remaining attached tissues separated from it. If the bleeding be excessive, it may be checked by the use of very hot water.

What dressings are required after enucleation?

Pressure to check the bleeding is very rarely, if ever, necessary, and, if resorted to, should be removed as soon as the bleeding is stopped. For the great mass of cases it is best to wait until all the bleeding ceases; wash out the cavity with an antiseptic solution, and then apply just enough absorbent cotton to take up the oozing—making no pressure, but leaving absolutely free drainage. It is possible that tight bandaging is responsible for some of the cases of meningitis that have occurred after enucleation.

What may be done to increase the mobility of the artificial eye worn after enucleation?

As the first step in the operation of enucleation, each of the tendons of the recti muscles may be grasped with forceps and raised from the eyeball, and a suture passed through the fold of tissue thus secured, about a half inch back from the cornea, as illustrated in Fig. 56. A globe of glass or metal, such as is used to place in the sclera after evisceration, may be inserted in place of the eyeball. The opposing recti muscles may be brought across this globe and sutured; and afterward the conjunctiva brought together by additional sutures.

What is the operation of evisceration?

By it the cornea and a ring of sclera 1 or 2 mm. wide are removed, and the remaining contents of the globe scooped out,

leaving only the clean scleral cup. The interior of the sclera is then to be washed out with a mercuric chlorid solution, or cauterized with strong carbolic acid, and the margins of the conjunctiva brought together with a suture. The stump thus obtained at first gives better mobility to the artificial eye than is usually secured after enucleation, but it gradually shrinks, and ultimately gives no more motion than does a good enucleation.

What is implantation of an artificial vitreous?

After evisceration, a sphere of glass, aluminum, silver, or gold is set into the empty sclera, care being taken to thoroughly remove all the scleral contents, check all bleeding,

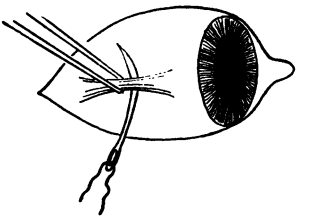

FIG. 56.—Method of stitching tendon to conjunctiva before enucleating the eye to increase the movement of an artificial eye.

and have the parts thoroughly aseptic. The scleral opening is then closed over the ball with a row of close, fine sutures, the angles of the wound being trimmed to fit as nearly as possible. The artificial vitreous must be small enough to permit the closure of the sclera without tension on the sutures. The conjunctiva is then closed with a row of sutures arranged at right angles to the scleral sutures. There is some risk of excessive reaction after such an operation, and in a considerable proportion of cases the artificial vitreous is subsequently extruded. But if it is retained, a very satisfactory and freely movable stump is the result. The operation is not so certain to prevent sympathetic disease as is enucleation, but probably greatly diminishes the chances of such disease.

What is the treatment when sympathetic inflammation has actually occurred?

The exciting eye with a piece of its optic nerve, unless that eye be capable of useful sight, should be excised; the sympathizing eye should be put under atropin, and the patient confined to bed in a dark room until the inflammation is fairly subsiding. The eye should be bathed with hot water; quinin and tincture of iron should be given freely, with a moderate mercurial treatment. With recovery the eye must be gradually accustomed to light and use.

Many months must pass after complete recovery before the eye can be pronounced free from danger of relapses; and during this time great care should be exercised, both as to the use of the eye and the general health of the patient. Eyes badly damaged by sympathetic inflammation sometimes offer hope of restoration to usefulness through operation. But at least two or three years of perfect freedom from inflammatory symptoms should be allowed to elapse before any such operation is attempted. The prospect of success will be better in proportion to the length of time the eye has remained quiet.

What are the different forms of artificial eye?

The usual shape (shown in Fig. 57) is that of a shell of glass or enamel, adapted to wearing over a stump furnished by a shrunken eyeball, or by implantation of an artificial vitreous. The double shell (shown in Fig. 58) is better

FIG. 57.—Artificial eye for wearing over a shrunken globe.

FIG. 58.—Artificial eye for wearing after enucleation.

adapted to cases in which enucleation has been done, since it better fills the cavity of the orbit, lessening the sunken look that an artificial eye generally has, and keeping the lids in position to favor the normal carrying off of tears.

What points must be considered in choosing an artificial eye?

1. Its size. If too small, it will appear sunken and will not properly support the lids. If too large, it will cause discomfort and irritation, and its movements will be unnecessarily limited. 2. Its shape also influences its comfort and mobility. Beside this, it must be so proportioned that when settled into position it will have the colored portion—the iris—properly directed, so as best to correspond with the natural eye, and not turned up or down behind the lids, or laterally, as in a case of squint. 3. The color should correspond to that of the natural eye, although exact similarity is not essential. This should include some correspondence in the size of the pupil when the patient is facing a good light—the condition under which differences between the two eyes would be most noticeable. 4. It should be perfectly smooth.

How is an artificial eye applied and removed?

Before it can be introduced the socket must be of sufficient size and proper shape, and must be free from obstructing bands of rigid tissue. To introduce it, the eye should be dipped in water and the broad outer segment slipped beneath the upper lid until the lower lid can be drawn down, so as to slip over the opposite edge of the shell. The lids may then be allowed to press upon the eye, which will quickly be pushed into the position in which its shape will retain it. To remove the eye, the lower lid is pulled down until the head of a pin or tip of the finger can be made to catch the lower edge of the eye. With this it is then guided out of the socket. Removal should at first be attempted while leaning over a cushion, so that if the eye slip out unexpectedly it will not be broken by the fall. An artificial eye should always be removed at night to permit the orbit to recover from any slight injury it may cause; and it should be placed in water that all adherent secretion may be soaked off. Even with this care the surface of the enamel will become roughened with two or three years' wearing, and the eye must be repolished or replaced with a new one, to prevent irritation of the conjunctiva that comes in contact with it.

DISEASES OF THE VITREOUS HUMOR.

What changes are produced by inflammation in the vitreous?

The bulk of the vitreous is rendered more fluid (*synchysis*), while dust-like, flake-like, linear, or membranous opaque masses or collections of pus are formed that interfere with vision.

What are the appearances of vitreous opacities?

When seen by oblique illumination, as they can be in the anterior portion, they usually have a gray appearance, though blood looks red or pus yellowish. With the ophthalmoscope they usually appear black against the red fundus, which they may hide entirely. When the vitreous contains crystals, as of *cholesterin*, which reflect the light, they appear as brilliant dancing points (*synchysis scintillans*).

How are vitreous opacities to be treated?

Dust-like opacity is generally due to syphilis, and is to be treated accordingly. Most others are only to be dealt with by treating the choroidal disease on which they depend. Dense membranous opacities, fixed behind the pupil, may sometimes be cut through with great advantage.

How are vitreous opacities to be divided?

A small Graefe knife is to be entered back of the ciliary region, toward the equator of the eyeball, in such a direction as to give the best access to the membrane it is intended to divide, but away from the larger perforating veins that are found in this region, and between rather than through the tendons of the muscles. The opening in the sclera should be made a subconjunctival opening by drawing the conjunctiva strongly to one side when the knife is inserted, so that when it is permitted to return to its usual position the cut in the conjunctiva will be some distance from the cut in the sclera. This operation is liable to be followed by intra-ocular hemorrhage, which will for a time prevent useful vision. Until the hemorrhage clears up the result of the operation cannot be known.

How does hemorrhage occur in the vitreous?

It comes from choroidal or retinal vessels as a result of injury or vascular disease. In the latter case it may be recurrent. It gives rise to dense opacity at first of a reddish hue, while the vitreous around it is misty. It may be quite absorbed after some time, but generally leaves some floating opacities and disturbance of vision. (See Proliferating retinitis, page 172.)

When are blood-vessels found in the vitreous?

They exist in it during early fetal life, and sometimes persist or leave opaque remains; the most common and important is *persistent hyaloid artery*, which comes off from one of the retinal vessels at the optic disk, and runs forward toward the posterior pole of the lens. Sometimes after repeated hemorrhages into the vitreous a mesh of newly developed blood-vessels, connected with those of the retina, is found extending into it.

What is pseudoglioma?

A collection of pus in the vitreous, giving rise to a light yellow reflex from back of the lens, resembling in appearance a case of glioma. It occurs after an attack of cerebrospinal meningitis or other disease liable to be attended with purulent retinitis or choroiditis. If the eye be free from irritation and the diagnosis certain, no immediate treatment may be required. But all the tissues of the eye are liable to undergo degeneration, and it may ultimately require removal for sympathetic irritation.

What parasites may be found in the vitreous?

The cysticercus of the ordinary tapeworm—*tænia solium*—is the most common. In certain parts of the world, especially in North Germany, it is not very rare to find it in this situation. In other countries its occurrence here is quite unknown. Its most typical appearance is that of a bluish-gray, translucent cyst, in which may be perceived the head and neck of the worm, which move slowly, apart from any movement of the eye. Sometimes the parasite has been noticed under the retina before breaking through into the vitreous. The treatment is removal of the cysticercus. Unless this be effected,

the eye is likely to become blind and shrunken. In a few instances echinococcus cysts and living filaria have been discovered in the vitreous, although their usual seat is outside of the eye in the orbit or lids.

DISEASES OF THE CRYSTALLINE LENS.

What are the normal changes in the lens produced by age?

The lens continues to grow in size so long as it remains clear; it also grows more rigid and more refractive, particularly the nucleus. Even in childhood some light is given back from the lens, causing the pupil to have a somewhat gray appearance by oblique illumination; and the amount of light so returned and the consequent grayness of the pupil continue to increase throughout life, so that in old age the normal eye presents an appearance that is very often mistaken for cataract. In the majority of cases the appearance of the pupil, as seen under ordinary illumination, is not to be relied on to indicate the presence or absence of cataract.

What is cataract?

Opacity of the crystalline lens or its capsule. Scientifically the term is applied to all kinds of opacities, but the laity understand it to be a progressive disease, or growth, leading to blindness, and in conversation with them the use of the term should be explained if applied to cases not likely to follow such a course.

What is senile or hard cataract?

The partial or complete opacity of a lens that has so far undergone senile change as to acquire a hard nucleus of some considerable size. It may occur in persons under middle age. In old people it is probably the rule, rather than the exception, that the lens shows some signs of beginning opacity, though a comparatively small number live long enough for the opacity to increase sufficiently to cause blindness.

What is nuclear cataract?

The form of senile cataract in which the opacity begins by a clouding of the nucleus (See Fig. 59). This clouding is commonly very diffuse and indefinite in boundary, and tends

to progress rather regularly, but very slowly. Its color inclines toward yellow or amber.

What is "second sight"?

A form of myopia that not rarely precedes nuclear cataract, and may be regarded as a sort of premonitory stage. It is

FIG. 59.—Nuclear cataract as seen with the ophthalmoscope.

due to increased refractive power of the nucleus of the lens, enabling the eye to see near objects with weaker lenses than have been required, perhaps, for many years, or even without any glass at all. But to a corresponding or even greater extent distant vision is rendered imperfect, with the probability that all vision will later be interfered with by further changes in the lens.

What is cortical cataract?

Senile cataract beginning in the cortex of the lens. It appears as well-defined masses or radiating lines of opacity, which at first are seen only at the margin of the pupil or behind the iris, and are most numerous in the lower part of the lens (Fig. 60). These opacities appear rather suddenly, and may remain for a long time stationary. Cortical is the more frequent form for senile cataract to commence in, but both nucleus and cortex are involved before the cataract becomes mature; and often the two forms of opacity are distinguishable in the same lens, while yet a considerable part of the lens is quite transparent.

FIG. 60.—Senile cortical cataract as seen with the ophthalmoscope.

What is soft cataract?

Opacity of a lens that does not contain any large, firm,

nuclear mass. It occurs mostly in young eyes that have not developed a hard nucleus, but is sometimes due to disintegration and liquefaction of the lens substance in later life. Its color is usually whiter than hard cataract and more uniform. A fluid cataract containing a hard nucleus is called a *Morgagnian cataract.*

What is diabetic cataract?

Opacity of the lens due to diabetes. It occurs in the later stages of that disease, runs a rapid course, and is hard or soft, according to the age of the patient.

What other varieties of cataract occur in the adult?

Choroidal cataract is the name given to nuclear cataract developing in connection with chronic choroidal disease. It develops very slowly and has a decidedly brown color. *Black cataract* those cases are called in which oblique illumination fails to show any decidedly gray appearance in the lens, even when the cataract is mature, because of its very dark brown color. *Complicated* a cataract is called when the eye in which it develops has been the seat of other serious disease. Extraction of such a cataract may be rendered more difficult by iritic adhesions; or the results may prove unsatisfactory because of a central choroidal atrophy, optic atrophy, or detached retina. Traumatic cataract is considered under injuries to the eye.

What are the different forms of congenital and juvenile cataract?

Complete, in which the whole lens is opaque. *Lamellar* or *zonular,* in which around a clear nucleus is found a layer of opacity, surrounded again by transparent lens substance. *Posterior polar,* in which there is a sharply limited opacity at the posterior pole of the lens. *Fusiform,* in which there is a spindle-shaped opacity in the axis of the lens; and *central* or *congenital nuclear,* in which the center of the lens is opaque, with no tendency of the opacity to involve other portions. Occasionally cataract develops during childhood, sometimes allied to congenital, sometimes to senile cataract. But arising at this time it is most frequently traumatic.

What are the symptoms of cataract?

Dimness of vision. This affects objects in all directions; but it may be rather worse for objects directly in front of the eye. It may vary considerably with the degree of illumination. Thus, when the principal opacity is nuclear, the vision will be worse with a pupil contracted as it is by a bright light, whereas if the opacity be at the margin of the lens, it will cause the least dimness when the pupil is contracted. Patients often believe their sight varies more from time to time than it really does. Cataract causes absolutely no pain or subjective symptoms other than the dimness of vision.

How is cataract to be recognized by inspection or oblique illumination?

The pupil, instead of black, will appear gray, yellowish-gray, or white. If of the latter color, or if the pupil presents distinct masses more gray or opaque than the substance surrounding them, this appearance may be sufficient foundation for a diagnosis. But where the gray hue appears uniform throughout the pupil, even though very marked, the lens may be quite normal. It is a common thing for the specialist to have cases referred to him as cataract on the strength of such a gray pupil, when the lens is really quite free from opacity.

What is the best method of determining the presence or absence of lens opacity?

Throw the light into the eye with the ophthalmoscope from a distance of eight to twelve inches, and ascertain if the red reflex that normally occupies the pupil is interrupted by points, lines, or masses of opacity which appear quite black. If the opacity be far advanced no red reflex will be seen, but the whole pupil will have much the same gray appearance it presents on oblique illumination. For this kind of examination no elaborate form of ophthalmoscope is required; any perforated mirror or piece of looking-glass with a hole scratched in the silvering, to look through, will answer the purpose. But the pupil should be somewhat dilated as by cocain, euphthalmin, or homatropin. The ophthalmoscope and oblique examination should both be resorted to.

When cataract is present, how shall its share in causing dimness of vision be determined?

By carefully observing what other causes of impairment of vision exist with it. Considerable opacity in the periphery of the lens may not prevent perfect vision, and when it co-exists with imperfect vision it may be possible by the use of the proper lenses to give normal sight. Or with the cataract there may be some incurable lesion like atrophy of the optic nerve, so that neither the removal of the cataract nor any other treatment will be of any avail. Note, also, if the dimness is about what the existing opacity would be likely to cause. If the opacity is not far advanced, the patient's vision should not be more interfered with than is that of the surgeon when he tries to see the fundus of the eye with the ophthalmoscope. If the fundus is no longer visible, test the power to recognize changes in the brightness of light, *quantitative light-perception*, as by turning a lamp-flame up or down, or passing it nearer to or farther from the patient's eye. Also test the power of *projection*, the power of recognizing the direction of the light when held in different parts of the field of vision. In uncomplicated cataract, light projection and quantitative perception are good. A cataract must be very dense to prevent the counting of fingers held close before the eye.

When is a cataract mature or ripe?

When the layer of lens substance next under the capsule has all become opaque. It will then separate easily and entirely from its capsule, and is in favorable condition for removal.

How do you ascertain if a cataract is mature?

By throwing a strong light obliquely into the pupil the margin of the pupil is made to throw a shadow upon the opacity; when clear substance still remains between the iris and the opacity this shadow is broad, but if the opacity extends to the surface of the lens the shadow will be very narrow. With the pupil dilated, the ophthalmoscopic examination will reveal some indication of red fundus reflex until the cataract is well advanced toward maturity.

What is the natural history of cataract?

It remains stationary for a time, or increases until the whole lens becomes opaque. Then the lens slowly diminishes in bulk, the fluid being absorbed, and the residue tending to become calcareous. Sometimes in children, and very rarely in old persons, it is finally, after some years, absorbed entirely. More frequently the suspensory ligament atrophies and the lens is dislocated, leaving the pupil clear, but endangering the sight of the eye by the presence in the vitreous of a mass that tends to act as a foreign body. Hypermature cataract remaining in normal position may act as a foreign body.

What can be done to prevent cataract?

The nutrition of the lens is intimately connected with that of the coats of the eyeball; it is probably deranged by any persistent eye-strain or other cause of congestion. Cataract is very frequent in eyes that are myopic, with choroidal lesions. So the avoidance of eye-strain is clearly indicated as a preventive. It is probable that senile opacities form or increase most rapidly during periods of impaired general nutrition, so that anything that preserves health may delay the development of cataract. Uncinariasis and exposure of the eyes to excessive heat, as by glassblowers, are avoidable causes.

What can be done for incipient or partial cataract?

Treat complications to which part of the failure of vision may be due, and adjust the glasses that will give the best vision. When the opacity involves the center of the lens, try if dilatation of the pupil improves vision. If it does, let a weak solution of atropin be used in the eye every two or three days so long as it has the desired effect. If the opacity be at the periphery of the pupil, try if vision can be improved by the use of pilocarpin, which contracts the pupil. Encourage the patient to drink water freely.

How may the maturity of a cataract be hastened?

By drawing off the contents of the anterior chamber so that the lens will fall against the cornea, the pupil being somewhat dilated with cocain, and doing massage. This may be done through the cornea, either with or without an iridectomy.

This is called *indirect trituration* of the lens, or if iridectomy is done, *Foerster's operation;* or by introducing a spatula into the anterior chamber and making *direct trituration* of the lens; or by making a small *opening in the anterior capsule* with a needle, and allowing the lens to become opaque and swollen from absorption of the aqueous. Operations for this purpose are rarely necessary or advisable.

When should we attempt to bring about the removal of cataract by absorption?

When the patient is under twenty-five years of age, and there is no reason to suspect an unusually large or hard nucleus; and the opacity of the lens is complete, or so far interferes with vision that the probable improvement to be attained will more than compensate for the inconvenience of wearing strong lenses.

What is discission of the lens; and what treatment is subsequently required?

Cocain having been instilled, and the pupil previously dilated, a Bowman stop-needle (see Fig. 61) is pushed through

FIG. 61.—Bowman's stop-needle.

the corneal limbus, and made to lacerate the anterior capsule of the lens at the center of the pupil. It is best to make but a slight laceration at first, and repeat if necessary. This will be followed by the swelling of the neighboring lens substance, and the opacity of any that has remained clear up to this time. Pieces of the lens substance may be pushed out into the anterior chamber, and gradually it is dissolved in the aqueous humor, and the lens shrinks until it is entirely absorbed. During this period the pupil must be kept fully dilated; and if at any time great swelling of the lens, iritis, or secondary glaucoma should develop, an incision should be made in the cornea, and the lens extracted at once.

When should a cataract be extracted?

If in a person over the age of twenty-five, if it is sufficiently

advanced to prevent useful vision, and the eye is free from any purulent discharge, and the patient's health fair. The most favorable condition for extraction is that of recent maturity, but when both eyes are so affected that useful vision has been lost, even though neither cataract is mature, it is best to extract the one that is the more advanced.

How is a fluid cataract removed?

By making an incision through the cornea and a free opening in the lens capsule with the point of the knife, spreading apart the lips of the corneal incision, and making pressure on the eyeball. To get all the lens substance out of the capsule it may be needful to gently press the ciliary region through the closed lids, and then again to open the corneal wound and allow it to escape from the anterior chamber. Sometimes the lens substance is removed by suction through a sort of cannula that is introduced through the incision.

How is the eye prepared for cataract extraction?

It should be free from any signs of inflammation, and particularly free from any infection of the conjunctiva or the lacrimal passages. It should be washed two or three times, at intervals of a few hours, with trikresol solution or physiologic salt solution, but should not be left bandaged more than an hour or two prior to the operation. For simple extraction, the pupil must not be dilated except by a drop of cocain solution used an hour or so before the operation. For extraction with iridectomy, the pupil may be previously dilated with atropin. Immediately before operating the conjunctival sac, lids, face, and especially the eyebrows and lashes should be thoroughly cleansed.

What instruments are required for cataract extraction?

A stop-speculum, such as is shown in Fig. 23; forceps for fixation, by seizing the conjunctiva near the limbus (see Fig. 62); a cataract-knife (see below); a spatula and a lens-scoop, for making pressure and counter-pressure on the eyeball, to secure expulsion of the lens. In addition to these, a cystitome or needle will be required if one prefers to open the lens capsule with such an instrument. Iris-forceps and iridectomy-scissors are also needed for the combined opera-

tion; and since it may be necessary to do iridectomy in any case, on account of a tendency of the iris to prolapse, not previously expected, these instruments should always be prepared

FIG. 62.—Fixation-forceps.

FIG. 63.—Wire loop.

for use, as should also a wire loop for extraction of the lens (see Fig. 63), in case it should become dislocated by some sudden movement of the patient.

What are the different forms of cataract-knife?

Beer's knife, shown in Fig. 64, is intended to complete the corneal incision by one forward thrust. The Graefe knife,

FIG. 64.—Beer's cataract-knife.

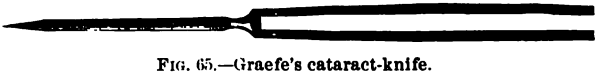

FIG. 65.—Graefe's cataract-knife.

shown in Fig. 65, is intended to make a puncture and counter-puncture, fixing the two ends of the incision, and then to cut

its way out by a to-and-fro movement. The author's knife (Fig. 66) is to be thrust forward until its broadest portion has

FIG. 66.—The author's cataract-knife, latest model.

entered the cornea, and the narrow bridge of tissue then remaining is to be divided as the knife is drawn back.

What is the operation of simple or flap extraction?

The eye having been cocainized and the conjunctiva washed with a trikresol or normal salt solution, the lids separated by a stop-speculum, and the movements of the eye controlled by forceps, such as are shown in Fig. 62, a cataract-knife is entered a little above one end of the horizontal diameter of the cornea, brought out near the other end of the same diameter, and a semicircular incision in the corneal margin completed upward. The capsule of the lens is then freely lacerated with the point of the cataract-knife or a cystitome. The margin of the lens nearest the corneal incision is then made to present in the pupil by pressing backward on the opposite margin, and when this occurs the pressure is increased and changed in such a way as to push the whole lens through the pupil and into the corneal wound, and this pressure must not be relaxed until the thickest part of the lens has emerged from the corneal wound. The lens is then lifted away and the eye allowed to close and rest. Portions of the cortex remaining should be carefully removed from the anterior chamber by pressure, or by washing out by a stream of a boric or a salt solution.

What is the modified linear, or combined extraction?

The extremities of the incision are made in the extreme corneal margin, and the center of it somewhat within the upper border of the cornea, after this the iris is drawn out and a portion of it excised. Then the capsule is ruptured and the lens extracted, much as in simple extraction. It is generally regarded as safest to divide this operation by doing what is then called a *preliminary iridectomy* some weeks

before the extraction of the lens. For an uncomplicated case with a mobile pupil the simple extraction is to be preferred.

What accidents or complications may attend cataract extraction?

The iris may fall in front of the edge of the knife before the corneal section is completed. This is most likely to happen with the narrow knife. By lifting the cutting edge slightly it may often be freed from the iris, and the section completed without further trouble. If this cannot be done, the iris must be cut; or the knife withdrawn and the operation deferred until another day. The corneal section as originally made may be too small. It must then be extended by the use of a special knife or the iris-scissors. A sudden movement of the eye, or the wrong application of pressure to it, may cause the lens to be dislocated without presenting in the corneal section. This allows the vitreous to escape in front of it. Delivery of the lens in the usual way is thus rendered difficult or impossible. It must be removed by the wire loop.

What is a loop extraction?

One in which, on account of the vitreous being fluid, or presenting in the corneal wound, or for other reasons, the pressure necessary to force out the lens cannot be applied. A lens-scoop or spoon, or better, the wire loop, is passed behind the lens, and it is coaxed or lifted out with it without pressure on the eyeball.

How is the eye to be treated after cataract extraction?

All shreds of tissue having been removed from the corneal wound, and the eye cleansed, and after simple extraction eserin instilled, a little absorbent cotton is to be placed on the lids of both eyes, not to make any pressure, but to absorb any discharge. This is to be retained by a strip of adhesive plaster passing from the cheek to the brow; a similar dressing should also be placed over the other eye. This dressing is to be removed and the eye cleansed once daily, until about the sixth to the tenth day, when the dressing may be omitted and both eyes left uncovered. It is usually best for the patient to remain in bed for three or four days, keeping as quiet as pos-

sible, yet not in one fixed position so long as to cause nervousness and involuntary movements. Exposure to very brilliant light or to sudden changes of light should be avoided until the eye is free from hyperemia.

What complications may arise after cataract extraction?

In a few cases hemorrhage from the depth of the eyeball occurs, causing destruction of the eye. It is attended with severe pain; it is most likely to arise in fleshy persons, and in eyes that have been the seat of increased tension; it may be guarded against by keeping the patient in a sitting posture for some hours after the operation, and after that with the head somewhat elevated.

What is the danger of prolapse of the iris?

This occurs in 8 to 12 per cent. of cases of simple extraction. Usually it begins within forty-eight hours after the operation. When first detected the prolapse may be cut off and the iris freed from the corneal wound, but the author usually prefers to allow the prolapse to remain untouched, the iris healing in the wound and causing a pupil similar in appearance and usefulness to that left after iridectomy. In cases treated by this method, the healing is somewhat prolonged, but the final result is good, and we avoid a certain risk of general inflammation of the eyeball that seems to attend the excision of a prolapse of the iris, unless done immediately after its occurrence.

What is the prognosis for cataract extraction?

Nineteen out of twenty eyes are restored to useful vision.

What is secondary cataract?

The capsule of the lens, with or without any remaining lens substance, or inflammatory exudate, sometimes becomes opaque, and thus interferes with vision. When at all dense, this opacity of the capsule is called secondary cataract.

What is to be done for secondary cataract?

To obtain the best vision, an opening must be made in the capsular membrane. This opening need not be large, but it should be quite clear. Over 50 per cent. of all cases of cata-

ract extraction will have vision decidedly improved by such an opening in the capsule within a few weeks after the extraction. In most of the other cases the thickening of the capsule, within two or three years after the primary operation, will be such as to seriously impair vision.

How do we operate for secondary cataract?

A knife-needle (see Fig. 67) is to be introduced through the vascular tissue of the corneal limbus, and with it two incisions made in the membrane that obstructs the pupil, forming a T or inverted V. The entering of the needle through the limbus

FIG. 67.—Knife-needle for secondary cataract.

is very important because it gives a larger leverage, making a sufficient cut in the capsule much more certain. Then, too, the vascular tissue heals in a few hours, preventing infection. Where the needle has been introduced through the clear cornea, infection is liable to occur for many days; and more eyes have been lost of late years by infection after this operation than after cataract extraction.

What lenses are required after removal of cataract?

Usually a strong convex, spherical lens, with a strong convex cylinder, having its axis approximately parallel to the line joining the ends of the corneal section. The hyperopia caused by the removal of the crystalline lens varies with the previous refraction of the eye. In a previously emmetropic eye, it will be 10 or 12 D. In an eye previously hyperopic, the spherical lens for distant vision may need to be still stronger. In an eye previously myopic, it will need to be weaker. Shortly after cataract extraction the astigmatism, which is against the rule, is almost always very high. But it gradually diminishes until, within from two to six months, it is reduced to 3 D. or less. The patient, being entirely deprived of accommodation, will require an additional convex lens of about 3 D. or 4 D. for near work.

What are the congenital anomalies of the lens?

Dislocation, in which the lenses are generally clear and sometimes may be made to present in the pupil, or to drop away from it at will, by a change in the position of the head. Congenital *coloboma* of the lens, in which one side of the lens is notched or deficient, often in a direction corresponding to a coloboma of the iris or choroid. *Aphakia*, absence of the lens as a congenital anomaly, causes high hyperopia, and absence, from childhood, of all power of accommodation.

DISORDERS OF TENSION OF THE EYEBALL.

What is the normal tension of the eyeball?

It is the normal outward pressure of its contents. It is necessary to keep the cornea in proper form, the dioptric surfaces the proper distance from the retina, and to enable the extra-ocular muscles to act well on the sclera. It equals usually about thirty millimeters of mercury, but may vary considerably in health.

What is glaucoma?

It is abnormally high tension of the eyeball, with the phenomena intimately associated with such high tension. The increase of tension may be brought about either by increase of the fluid taken from the blood-vessels and poured into the eyeball, or by the checking of its escape from the eye, which takes place mainly at the periphery of the anterior chamber.

What are the subjective symptoms of glaucoma?

Impairment of vision and pain in and about the eye. Often there are colored rings or halos around any source of light, but these may not be noticed, and are not peculiar to glaucoma. The failure of vision is usually not uniform. There will be marked, even rapid failure, followed by partial recovery, only to be succeeded by worse failure until all perception of light is lost. The pain is felt in the eyeball, or may be referred to the brow or side of the nose, or the cheek. It presents exacerbations and remissions. It is in some cases absent, especially in the earlier stages of the disease, but it may be the most intense aching or neuralgic pain that is ever suffered.

How is the field of vision affected in glaucoma?

It is always contracted. Generally the contraction is irregular. It is often most contracted on the nasal side. It may, however, present sharp re-entering angles, or scotomas, or islands of retained vision in areas otherwise blind. The field sometimes becomes very greatly narrowed before central vision is much affected. Changes in the field are often the best indication of the progress of the case.

What symptoms are discovered by external examination of the eye?

The testing of the tension of the eyeball, previously described (see page 76), shows it to be abnormally high. The cornea is less sensitive to touch than normal, and may be hazy. This haziness, when present, is uniform throughout the whole cornea, and indicates a recent considerable rise of tension. In the inflammatory form of the disease there is a marked zone of pericorneal redness during the exacerbations. In old cases, the veins which emerge from the sclera a few millimeters from the edge of the cornea and pass backward are enlarged and tortuous. The pupil is sluggish, often widely dilated; and the iris may be seen to be very close to the cornea, making the anterior chamber shallow.

What are the ophthalmoscopic symptoms?

The media may be so hazy as to prevent any clear view of the fundus, but the most constant symptom of glaucoma, except in recent cases, is a cupping of the optic disk. The glaucoma cup differs from the physiologic cup, in extending the whole width of the disk, and from other excavations of the disk in having abrupt or overhanging sides. And as the retinal vessels pass down the sides of the cup they disappear, so that the part at the bottom of the cup seems disconnected from the part in the retina. Visible pulsation of the retinal arteries, either spontaneous or producible by slight pressure on the eyeball, is another evidence of high tension; it is noticeable where the artery bends over the edge of the cup.

With what affections is glaucoma likely to be confused?

Inflammation of the cornea when that membrane is hazy

and surrounded by a zone of redness. Iritis, in the same conditions. Remember that in iritis the pupil is contracted. Trifacial neuralgia, when there is pain, or sick headache, for the intense pain may cause vomiting. Meningitis, erysipelas, and grippe have been diagnosed in cases of glaucoma.

What are the different varieties of primary glaucoma?

Simple, where the eye is free from inflammatory symptoms. This runs a comparatively slow course with little pain until the latter part, and it is but slightly amenable to treatment. *Inflammatory*, marked by exacerbations, attended with redness, pain, and dilated pupil. It can generally be cured by iridectomy. *Glaucoma fulminans* is the name given when, in the course of one of the other varieties, there is a sudden enormous rise of tension, complete loss of sight, and other violent symptoms. *Malignant glaucoma* is the term applied to cases in which another violent outburst occurs shortly after the performance of an iridectomy. When the eye has become quite blind and the high tension permanently established the glaucoma is said to be *absolute*. Sometimes glaucoma is preceded by numerous retinal hemorrhages, after which it runs an unfavorable course. It is then called *hemorrhagic glaucoma*.

What is the prognosis of glaucoma when not treated?

Complete and irremediable blindness, with partial degeneration of the inner coats of the eye, and for a period more or less prolonged, a painful globe. Absolute blindness may be reached in a few hours, or only after many years. As a rule, the sight that has already been lost by glaucoma cannot be restored; only the retention of what remains is to be hoped for.

What is the treatment for glaucoma?

No treatment will restore the vision that has been lost more than two or three weeks. To permanently check the process, some operation must be done on the eyeball. *Iridectomy* is the most important. *Sclerotomy* and *sympathectomy*, removal of the superior ganglion of the cervical sympathetic nerve, are also done.

How should iridectomy be done for glaucoma?

If there be any hyperemia of the eye, general anesthesia must be employed. On account of the shallowness of the anterior chamber, it is best to make the incision through the cornea with a narrow cataract-knife. The incision should be well into the limbus, allowing the iris to be removed clear up to its ciliary attachment. Fully one-fifth of the iris should be excised. It is commonly done upward where the resulting coloboma will be concealed by the lid (see Fig. 68).

What is sclerotomy?

Anterior sclerotomy is an incision made with a narrow cataract-knife somewhat like the incision for simple extraction, but placed as far back toward the root of the iris as possible, and the incision left uncompleted, a bridge of tissue remaining uncut at its middle (see Fig. 69). It may be resorted to

FIG. 68.—Iridectomy for glaucoma.

FIG. 69.—Sclerotomy for glaucoma.

for hemorrhagic glaucoma, or for absolute glaucoma to relieve pain. In posterior sclerotomy, the incision is commonly made between the insertion of the tendons of the external and inferior recti muscles. Through this enough of the vitreous is allowed to escape to diminish, for the time, the intra-ocular tension. It may be resorted to as a preliminary to iridectomy, or for patients unable to bear general anesthesia, and in whom little is to be gained beyond the relief of pain.

What is the value of sympathectomy for glaucoma?

Removal of the upper ganglion of the cervical sympathetic causes in normal eyes myosis and decided reduction of the intra-ocular tension. It is proper to resort to this operation in cases of hemorrhagic or simple glaucoma, in which varieties iridectomy has proven least reliable; or in any case if iridectomy has failed to check the course of the disease.

What is the influence of massage in glaucoma?

It temporarily lowers the intra-ocular pressure and, if the eyeball be not too tender, may be tried at short intervals when more radical treatment cannot be carried out.

How should myotics be used for glaucoma?

Eserin should be instilled in proportion of ¼ grain to the fluidounce, or enough stronger to produce contraction of the pupil. Unless this contraction can be secured, the myotic will be of little or no benefit. If the same contraction can be obtained with pilocarpin, this may be employed. The myotics are useful in reducing the tension temporarily until an iridectomy can be done, or until the patient will consent to an operation. Or they may be valuable in preventing pain in an eye that is already blind. But if glaucoma is clearly present, and useful sight still remains, myotics should not be relied on to the exclusion of iridectomy.

What general treatment should be used in glaucoma?

The general regimen for the uric-acid diathesis, eliminative measures, rest for the nervous system, sleep and freedom from worry. Sometimes a brisk purge will cut short an attack. But these measures should be regarded merely as palliative or adjuvant to operative treatment.

What is hydrophthalmos or buphthalmos?

A condition in which the eyeball becomes distended and enlarged because of congenital interference with the escape of fluid from the angle of the anterior chamber. It is a congenital or juvenile glaucoma. The eye becomes enlarged, the sclera thinned and bluish in appearance, and vision is gradually lost. Iridectomy or sclerotomy should be tried, and in some cases seems to check the process.

What conditions are attended with diminished tension of the eyeball?

Perforating wounds, corneal fistula, and chronic iridocyclitis. Bruise of the eyeball may diminish its tension for several weeks. *Ophthalmomalacia* is a rare condition of diminished tension, attended with pain, photophobia, and

deep hyperemia, coming on without known cause, lasting several hours or days, and ending in recovery.

DISEASES OF THE RETINA.

What are the symptoms of retinitis?

Dimness of vision or blindness, usually confined to the portions of the field of vision corresponding to the parts of the retina involved; swelling and opacity of the retina, also localized. The swelling may amount to two or three times the thickness of the normal retina. The opacity varies from a faint bluish-gray veiling of the normal red of the fundus to a brilliant white. Retinitis is also very generally attended with hemorrhage. It does not directly give rise to pain, but the inflamed retina is sometimes a source of discomfort by over-sensitiveness to light. Subjective sensations of light may be noticed.

How does purulent retinitis occur?

By metastasis in pyemic or septicemic diseases. It may be confined to numerous scattered dots of exudation and hemorrhage, visible with the ophthalmoscope; and end in partial or complete recovery, if the patient survive the original disease. Or it may extend, causing a permanent pseudoglioma, or a panophthalmitis ending in complete loss of the eye.

What is the appearance of hemorrhage into the retina?

That of a dark red mass or area in the level of the retina. If the hemorrhage be in the superficial layer, which is that of the nerve-fibers, its shape is largely due to the ease with which it spreads in the direction of these fibers, and its margins have a gradually shading or "feather" edge; such hemorrhages are often described as "flame-shaped." If in the deeper layers, the hemorrhage has a sharper and more rounded boundary. Retinal hemorrhages undergo gradual absorption, leaving black spots of accumulated pigment or areas of atrophy.

What is subhyaloid hemorrhage?

Hemorrhage from the retinal or choroidal vessels, which breaks through the retina and spreads out into a rounded

patch upon its surface. It appears to the patient like a cloud, that is red, at least, at the edges. With the ophthalmoscope, it may be seen gradually to shift its position from day to day. With absorption of the blood, vision may be restored to normal, even when the hemorrhage has occupied the region of the macula.

What is albuminuric retinitis?

A form of chronic retinal inflammation or degeneration occurring in connection with chronic Bright's disease, or severe albuminuria of pregnancy. In the latter case it may, on the termination of pregnancy, end in almost complete recovery and good sight. In connection with chronic kidney disease it is probably always a late symptom, though often the one that leads to the first recognition of the malady. It is intimately associated with the degenerative changes in the vascular walls. Complete recovery cannot be hoped for in the retinal condition, and its existence indicates the probability of a fatal termination of the case within a few months or a year or two. Generally both eyes are affected, though in different degrees.

What are the usual appearances of albuminuric retinitis?

The small patches of exudation or degeneration are of a brilliant white. In the region of the macula, where they are apt to appear early and be most numerous, they are more or less arranged in lines radiating from the fovea. Large masses of exudation may have a pale, dirty brown color. There are hemorrhages, often many small ones; and sometimes black specks marking the site of former hemorrhages. The retinal vessels show signs of disease, sometimes aneurismal dilatations, sometimes white opacity of their coats. The appearances of the chronic degenerative form of the disease are indicated in Fig. 70.

What importance attaches to albuminuric retinitis during pregnancy?

It always indicates grave uremic poisoning. But with the termination of pregnancy, and the cessation of albuminuria, there may be great improvement in the retinal condition, though generally not complete recovery. Subsequent

pregnancies may not be attended with albuminuria or retinitis, and the patient may continue in good health. But if the retinal condition become so grave as to threaten or produce blindness, it is proper to terminate the pregnancy at once, not only to give the patient the chance of recovering vision, but

FIG. 70.—Albuminuric retinitis (after Jaeger).

also because the uremic condition threatens her life and renders improbable the birth of a healthy child.

What is leukemic retinitis?

A special form of retinitis that attends advanced leukemia and pernicious anemia. The exudation is here more general, giving rise to large, diffuse gray opacities. Hemorrhages are numerous and often large. The vessels are all pale, and the arteries small, but the veins appear unusually broad, with a broad light streak upon them. This widening and pallor of the veins may be found in any severe anemia.

What are the characters of syphilitic chorioretinitis?

Points or small areas of retinal opacity appear. These may be massed around the optic disk or macula. There are also spots of choroidal infiltration and, later, of pigment disturbance. Dust-like opacity of the vitreous is present. The

optic disk is red and hazy, or opaque, and later becomes yellowish-white, and partially atrophic. Retinal hemorrhage is rare, but may occur. These lesions may begin in the secondary stage and run on well into the tertiary stage. Vision is always impaired, and there may be night-blindness and a persistent quivering of objects, or metamorphosia, that is very annoying. In typical cases these lesions are quite characteristic of syphilis. Under the use of mercury and iodids the disease is checked; and vision is improved, but it is rarely restored to normal.

How is retinitis caused by exposure to excessive light?

Exposure to the direct rays of the sun or to the electric arc-light at too short a distance causes, in the region of the macula, a localized retinitis and central scotoma, which may be permanent or may be recovered from, according to the grade of injury. It is most likely to arise after watching an eclipse of the sun or sun spots, or from working about an electric arc-light without proper protection to the eyes. When due to the latter cause, the retinal lesion may be attended by intense pain, swelling, and injection of the conjunctiva covering the globe and lids.

What are the other important varieties of retinitis?

A condition of impaired vision, not progressive, attended with great numbers of white or yellowish-white points scattered throughout the retina, probably due to some earlier retinal disease, is called *punctate retinitis.* A form characterized by brilliant white spots arranged in the form of a wreath around the macula, or about the macula and optic disk, is called *circinate retinitis.* These white spots may take their origin in hemorrhages. The disease occurs after middle life, is to some extent progressive, but does not go on to complete blindness. *Striate retinitis* is the name given when long narrow streaks of yellowish gray are found just back of the retinal vessels. These streaks may mark a previous detachment of the retina. Vision is impaired, but not generally lost. Retinitis, usually attended with hemorrhage into the vitreous, may be followed by the formation of gray or bluish-

white bands or masses of connective tissue in the vitreous. To this condition the name of *proliferating retinitis* is given.

What is the treatment for retinitis?

First, the treatment for any constitutional condition causing it. Complete rest for the eyes, including the avoidance of sudden changes of light, and the use of the proper correcting glasses, if any are required. After the acute stage has entirely passed, if there tends to be any permanent scotoma or atrophy, strychnin may be given.

What is retinitis pigmentosa?

A degenerative affection of the retina, mostly due to congenital or hereditary causes, usually beginning in childhood, and running an extremely chronic course to complete blindness at about sixty years of age. It is characterized by night-blindness, great concentric contraction of the field of vision, and the deposit of black pigment in the retina, in isolated masses of peculiar shape, something like that of a bone-corpuscle; appearing first and being most numerous in the periphery of the retina. It is not amenable to treatment. It may also arise as a manifestation of tertiary syphilis. In which case it may be checked by treatment without going on to complete blindness.

What is amaurotic family idiocy?

A degenerative disease of the retina and brain-cortex, of congenital origin, and often seen in several children of the same parents. It arises in early childhood, attention being attracted to the progressive muscular weakness of the child and its inabilily to see. The ophthalmoscope shows the center of each retina to be occupied by a rounded area of gray or white, in the midst of which the center of the macula appears as a dark red or brown spot. Optic atrophy occurs, the child becomes entirely blind, and progressively weaker until death ensues. The reported cases have been of Jewish parentage.

What are the symptoms of retinal thrombosis or embolism?

Sudden dimness of vision, usually passing quickly into absolute blindness, over nearly or quite all of the field of

vision; generally permanent, but in a few cases followed by recovery of vision, either partial or complete. With the ophthalmoscope, the vessels may be found diminished, and the veins irregular in caliber. The central part of the retina is hazy. The edema partially conceals the retinal vessels and the choroid, except at the fovea, where a small spot retains about its normal color and stands out dark red, in contrast with the surrounding gray retina. Subsequently the fundus returns to its normal color, the vessels contract still further, or become obliterated and replaced by white streaks, and the nerve undergoes atrophy. It is often uncertain as to whether embolism or thrombosis is present. But in the absence of any discoverable source for an embolus, and in cases in which the onset of the symptoms is gradual, or in which previous attacks of temporary obscuration of vision have occurred, the condition is probably one of arterial thrombosis. Thrombosis of the retinal veins presents also dilatation of these vessels and hemorrhages in the retina.

What is the treatment for the above conditions?

If due to embolism, an effort should be made to break up or dislodge the plug, so that it may be carried into vessels at the periphery of the retina, where the disturbance caused by it will be of little importance. To effect this, inhalations of amyl nitrite sufficient to produce decided dilatation of the peripheral vessels should be employed, with rather vigorous massage of the eyeball. These should be repeated once or twice a day for several days, since a plug that cannot be dislodged at first may subsequently shrink or become disorganized and broken up. For venous thrombosis the eye should at first be kept quiet. In only a few cases of either embolism or thrombosis has there been any restoration of vision; and in very few has it been complete. When vision has been partially restored, strychnin may be of service.

What is detachment of the retina?

The separation of the retina from the choroid by a serous fluid, on which it floats with a tremulous movement from every change of position of the globe. It is distinguished from other opacities in the vitreous chamber by its uniform

membranous appearance and the retinal vessels that may be seen on it. It may be caused by a blow on the eye or by shrinking of the vitreous from chronic disease, and it is very apt to occur in high myopia. It causes sudden interference with vision, which may vary when the anterior portion is detached, by its floating up in front of parts still unaffected. The detached portion generally soon loses its power of vision, but may recover it, if it becomes reapplied to the choroid. In general the prognosis is unfavorable, but in some cases sight has been restored spontaneously.

How should detachment of the retina be treated?

Rigid confinement to bed, with pilocarpin-sweats and complete rest of the eyes under a bandage or dressing, offer the best prospect of restoration. Drainage of the subretinal fluid by multiple punctures, and especially by rather large openings made with the galvanocautery, have some cures to their credit. If the patient possesses good vision in one eye, he will rarely care to submit to such severe treatment. But it is worth trying when the alternative is complete blindness.

What is glioma of the retina?

A malignant new growth, occurring congenitally or in young children. Starting in the retina, it fills the vitreous chamber with a mass that gives through the pupil a brilliant yellowish-white appearance, with fine blood-vessels upon it. It then pushes forward the lens, causes increased tension of the globe, with external redness, perforates the sclera or cornea, involves the contents of the orbit, and causes death by extension to the brain or by exhaustion.

How should glioma be treated?

The eye containing the tumor should be removed at the earliest possible moment, and with it the optic nerve as far as the apex of the orbit. If the growth has already extended beyond the eyeball, the whole contents of the orbit should be removed. Even this is very likely to be followed by recurrence and death. But after early removal of the tumor in the eyeball, the relief is permanent in perhaps one-third of all cases.

What is the condition of opaque nerve-fibers, or persistent nerve-sheath?

The occurrence in the eye of medullary sheaths to the axis cylinders which alone constitute the normal nerve-fiber layer of the retina. These sheaths are generally lost on entering the globe. When the nerve-fibers have such sheaths they cause a brilliant white patch, usually extending from the edge of the disk, upward or downward, in the directions normally taken by the nerve-fibers. This patch has a "feathered" edge. Over its area parts of the retinal vessels will be visible and other parts hidden in the opacity.

DISEASES OF THE OPTIC NERVE.

What is optic neuritis?

A plastic inflammation of the ocular extremity of the optic nerve. Probably in the great majority of cases the nerve and its lymph-channels are affected throughout its whole length; but it is on the ocular end that the violence of the disease expends itself. On this account it is sometimes called *papillitis*. It is also called *choked disk*, on account of the interference with the return of blood through the retinal veins, by pressure from the swelling at this point.

What are the ophthalmoscopic appearances of optic neuritis?

The small vessels are dilated so that more of them are visible than is normal, and a reddish hue is given to the disk. This reddening is as pronounced in the mild cases as in the severe, for in the latter the excessive edema masks the vessels. The retinal arteries are diminished in size, the veins are swollen and tortuous. The outlines of the disk are hidden by the edematous swelling (Fig. 71), and by the extent of this swelling the severity of the inflammation is mainly judged. The height of the swelling is measured by determining the refraction of its most prominent or hyperopic portion, and the refraction of a neighboring unswollen part of the fundus. Generally this swelling, and often the neighboring fundus, presents small hemorrhages.

How is the acuteness of vision affected in optic neuritis?

Generally it is somewhat impaired, but often so slightly as not to attract the patient's attention, and a very high grade of inflammatory swelling is not incompatible with vision quite up to the standard of normal acuteness. It is, however, liable to be lost as the inflammation passes over into atrophy. After being well retained for a long time it may be lost quite rapidly.

What are the causes of optic neuritis?

Coarse disease of the brain or its membranes, as tumor, encephalitis, meningitis, either tubercular or however pro-

FIG. 71.—Optic neuritis (after Meyer).

duced, hydrocephalus, etc., albuminuria, syphilis, and lead-poisoning. When due to any of these causes it commonly affects both eyes. A slight neuritis, showing no tendency to atrophy, is not rarely seen as an effect of eye-strain, particularly in school children. As a symptom of obscure brain-disease optic neuritis is often of the utmost importance, distinguishing, as it does, between functional and gross organic

disease. Suppression of menstruation, rheumatism, "cold," or inflammation about the orbit or in the sphenoid may cause it.

What is the connection of optic neuritis with brain-disease?

Increased *intracranial pressure* seems to be the most important factor in causing the neuritis. The relief of pressure by opening the skull will often produce marked improvement in the condition of the optic nerve, although nothing else may be accomplished. Direct extension of inflammation from the cranial cavity, the transmission of germs or toxins through the lymph-channels, vasomotor and trophic nerve influences have each been suspected of being the means by which the neuritis is produced.

What is the prognosis of optic neuritis?

This depends chiefly upon its cause. When due to eye-strain, recovery is generally complete. It is often complete when the condition arises from acute disease or poisoning. When due to an incurable brain-lesion, it may run a very chronic course, especially if such be the course of the brain-disease. But ultimately it is certain to pass over into optic atrophy with blindness, which is often complete.

What is the treatment for optic neuritis?

Complete rest of the eyes, and sodium or potassium iodid in doses rapidly ascending to the physiologic limit; with that of the general condition underlying it, upon the result of which the result of the neuritis must largely depend.

What is neuroretinitis?

Inflammation which involves to a marked extent both the optic nerve and retina. In all cases of severe neuritis, the swelling encroaches somewhat on the surrounding retina, and spots of exudation and hemorrhage may appear at points removed from the disk. Yet this would not constitute the case one of neuroretinitis. Neither are those cases included here in which, with general retinitis, there is some haziness of the optic disk, but without swelling, complete obscuration, or disturbance of the retinal circulation. The term is reserved for those cases in which the optic nerve and retina are both generally and decidedly involved.

What is retrobulbar neuritis, or central amblyopia?

It is an inflammation involving a limited portion of the optic nerve behind the globe, and causing interference with the vision at the fixation-point and in its neighborhood. Usually there is complete blindness for colors in this region, and decided impairment of vision for form, or black and white. This impairment of vision tends to persist and become permanent by atrophy. The ophthalmoscopic symptoms are limited to redness and haziness of the disk, which appear some days after the impairment of the vision; later, paleness of a sector of the disk, having its base toward the temple, may be noted. Certain of the toxic amblyopias exhibit the symptoms and pathologic changes of chronic retrobulbar neuritis, but with less ophthalmoscopic evidences of inflammation (see Toxic Amblyopias).

What are the causes and treatment of acute retrobulbar optic neuritis?

It arises most frequently in women during the period of active sexual life, and seems to be caused by exposure, rheumatism, syphilis, and other infectious diseases. The treatment includes rest for the eyes, pilocarpin-sweats, the administration of salicylates, and of mercury and potassium iodid.

What are the ophthalmoscopic appearances of atrophy of the optic nerve?

The disk is pale, of a bluish or grayish cast, or dead white. The small vessels have disappeared from its surface, and the retinal vessels are usually, but not always, contracted. The surface of the disk is cupped, the cup extending to the margins of the disk, with sloping, not abrupt, sides. Sometimes the area of the disk is markedly contracted.

What are the varieties of optic atrophy?

Atrophy occurring without antecedent disease is called *primary*. Ophthalmoscopically it is marked by distinctness of the nerve margin, the gray color of the disk, absence of small vessels, but no great contraction of the main trunks. *Secondary atrophy* is the term sometimes applied to all cases not primary; or, in a restricted sense, to include only those

that do not follow neuritis. *Consecutive atrophy* follows neuritis or retinitis, and may be called *postneuritic, retinitic,* or *choroiditic atrophy.* In it the larger retinal vessels are apt to be shrunken. *Gray* or *white atrophy* designate the color of the disk.

How is vision affected in optic atrophy?

There is always some limitation of the field, concentric in primary atrophy, irregular in postneuritic. The fields for colors are first reduced and to the greatest extent. Central vision is usually impaired also, and ultimately may be entirely lost. The impairment of vision is not at all closely proportioned to the pallor of the disk or other ophthalmoscopic symptoms.

What are the causes of optic atrophy?

All the conditions that may cause optic neuritis, also pressure on any part of the nerve, various forms of retinitis, embolism of the central artery of the retina, spinal disease, especially locomotor ataxia. It may arise as an independent affection, though many of the cases that seem to be of this class are but those of its occurrence as a premonitory symptom of sclerosis, which years later may involve the central nervous system. Certain forms of poisoning, especially lead-poisoning, cause optic atrophy. There is a form that is *hereditary,* affecting usually the males of a family, and appearing from early adult life to middle age. This form begins with a central scotoma.

What is the treatment for optic atrophy?

The removal or treatment of the conditions causing it, and the administration of strychnin in ascending doses until marked improvement occurs, or the physiologic limit is reached. It has been recommended to give the drug hypodermically, but it may be given as effectively by the mouth, and usually with less inconvenience.

DISEASES OF THE ORBIT.

What are the symptoms of orbital cellulitis?

Pain in the orbit, increased on pressure, and aching or

neuralgic pain referred to adjoining portions of the face. Great swelling of the lids, protrusion of the eyeball, and impairment of some or all of its movements. There may be impairment of visual acuteness, or even complete atrophy of the optic nerve from pressure; or optic neuritis may be set up by extension of the inflammation. Palpation may reveal some focus of the inflammation tending to point and discharge externally. The constitutional symptoms of inflammation are usually severe.

How is orbital cellulitis to be distinguished from other affections?

From *purulent conjunctivitis*, with great swelling of the lids, it is known by the absence of conjunctival discharge. From *panophthalmitis*, it is distinguished by the transparency of the dioptric media, and the absence of evidence of disease within the eyeball, except, possibly, distention of the retinal veins. From *thrombosis of the cavernous sinus*, it differs in absence of early palsies of the ocular muscles, and by the presence of inflammatory heat and tenderness of the orbital tissues.

What are the causes and treatment of orbital cellulitis?

Injury, including operative wounds, erysipelas, septicemia, or periostitis involving the walls of the orbit, may give rise to it, or it may be idiopathic. The special feature of its treatment is early, deep, and often multiple incision, preferably from the conjunctiva, and hot fomentations, to favor external drainage, keep down the destruction of tissue, and prevent intracranial extension.

Describe inflammation of the oculo-orbital fascia.

It may be caused by gout, rheumatism, influenza, or traumatism. It is marked by pain on movement of the eye, swelling, particularly of the upper lid, and conjunctival edema. It should be treated by rest of the eyes, hot applications, and internal medication directed to the cause.

What are the symptoms of orbital periostitis?

If very acute, most of those of cellulitis; but generally there is less swelling and less constitutional disturbance,

though the pain may be quite as great. In cases that do not tend to suppuration there may be only pain and tenderness on pressure.

What are the effects of caries of the orbit?

The establishment of a discharging sinus. This will require free opening, the removal of diseased bone, and thorough cleansing and drainage. It is liable by involvement of the soft parts to cause paralysis of one or more of the ocular muscles, or great deformity of the lids.

What are the symptoms of thrombosis of the cavernous sinus?

Paralysis of the ocular muscles, with sometimes anesthesia of the adjoining skin; exophthalmos, and edema of the lid and conjunctiva, which becomes enormous. There is dilatation of the retinal veins and, sometimes, optic neuritis. It may arise from infection, a malignant growth, or an injury.

How does disease of the frontal sinus involve the orbit?

The stoppage of the normal outlet causes accumulation of secretion until the sinus is filled; and after that a slow distention with thinning of its wall, which at length undergoes absorption. The cavity may be filled with the somewhat altered secretion of its lining membrane, *mucocele;* or with pus, *empyema.* A tumor presents, usually at the upper inner angle of the orbit, at first hard, but softening as the bone is absorbed. It is to be treated by opening freely, removing its contents, and then re-establishing the communication between the frontal sinus and the nose.

How may ethmoidal disease affect the orbit?

Mucocele or empyema tend to break down the thin bony walls, separating the ethmoidal sinus from the orbital cavity, allowing the extension of the accumulation into the orbit, disturbing the ocular muscles by pressure or forming an abscess. Pressure, probably from the related sphenoidal cells, through the thin walls of the optic foramen, may cause optic atrophy in rare cases of nasal polypus. Optic neuritis, arising probably by extension of inflammation through these

same thin walls of the foramen, may follow the use of the galvanocautery in the nose.

What is ivory exostosis?

A bony tumor of great hardness, which takes its origin from the ethmoidal or frontal sinuses and grows into the orbit, causing displacement of the eyeball and, later, pain. It is also liable to extend into the cranial cavity. It should be removed as early as possible.

How do dermoid cysts appear in the orbit?

Although congenital, they may remain unnoticed for several years. The cyst appears as a smooth, round, elastic tumor, closely connected with deeper structures, but not adherent to the skin. The tumor slowly increases in size.

How should such a cyst be treated?

If not very deeply connected, it should be dissected out. If too extensive for this, it may be opened, its contents washed out, and crystals of silver nitrate placed in it to produce destruction of the lining membrane, adhesive inflammation, and gradual obliteration of the cavity.

What other cysts occur in the orbit?

Encephalocele is congenital. It is reducible by pressure through passage of the fluid contents into the cranium, and it pulsates. It must be let alone, although the child is likely to die of the accompanying cerebral defect or of meningitis. *Microphthalmos*, excessively small eyeball; or congenital absence of the eyeball, is usually accompanied by a cyst that distends the lower lid. *Hydatid* and *echinococcus* cysts are found in the orbit. *Cavernous angioma* may have the characters of a cystic tumor; and orbital hemorrhage may be followed by a cyst.

What are the malignant tumors of the orbit?

Carcinoma involves the orbit secondarily from the lids, conjunctiva, lacrimal gland, or more distant organs. Sarcoma is liable to originate in the orbit, either within or outside of the eyeball, or to extend to it from the neighboring cavities.

If primary in the orbit it may be of very slow growth, but invading the orbit from other parts it is likely to grow rapidly.

How should malignant tumors in the orbit be treated?

Complete removal of the orbital contents is the only measure that is likely to be effective. In spindle-cell sarcoma, primary in the orbit, complete removal may effect a permanent cure. Removal of the growth may be indicated also to relieve pain or to remove temporarily unsightly deformity, but, with the exception above mentioned, it is not likely to effect a permanent cure, and often will not prolong life.

What other tumors occur in the orbit?

Tumor of the optic nerve causes early blindness and exophthalmos without much disturbance of the eye movements or early pain. It is usually a fibromyxoma in structure, and does not recur after removal. Removal should be practised as soon as the growth is recognized. *Lymphoid growths*, including *chloroma*, a light green tumor, occur in the orbit in connection with lukemia.

What is pulsating exophthalmos?

Swelling of the orbital contents with protrusion of the globe, pulsation, and a distinct bruit, were formerly regarded as evidence of true aneurism of the ophthalmic artery. It is now known that they may arise without any change in the vessels, that remains after death. The condition, however, may be due to arteriovenous aneurism, to aneurism within the cranium, or to malignant disease of the brain, or the neighboring bones.

What is exophthalmic goiter; Graves' disease, or Basedow's disease?

A disease of the central nervous system, in which, associated with great disturbance of the action of the heart and swelling of the thyroid, there is undue protrusion of the eyeball and retraction of the eyelids. The retraction of the lids greatly increases the appearance of exophthalmos, or may alone cause it (see Eye-symptoms of General Disease).

DRUGS AND FORMULAS.

How are instruments to be disinfected?

Most certainly by heat. Smooth, polished instruments, like knives, may be dipped repeatedly into boiling water and carefully wiped with absorbent cotton. Other instruments, especially such as are rough or jointed, should be boiled for several minutes in water, to which has been added a little caustic soda. If the instruments are kept in a tight box in which formaldehyd vapor is generated, either from paraform or from formalin dropped on absorbent cotton, they will remain aseptic. But they should be again cleansed before using.

What solutions of formaldehyd are used in the eye?

A 1 per cent. solution may be used as a local caustic or disinfectant. But the drug is very irritant, and a solution of

Formaldehyd	1
Distilled water	5000

is strong enough to employ for cleansing the conjunctiva. Even this will cause severe smarting and complaint from some persons. Formalin, the 40 per cent. solution of formaldehyd, must be used in two and one-half times the above proportion.

How is trikresol to be used in the eye?

In the following solution,

Trikresol	1
Distilled water	1000

it is an efficient antiseptic, and causes a very slight temporary sensation of burning. It is probably the best solution for cleansing the conjunctiva prior to operations, and is also of value as the basis of solutions of cocain, atropin, eserin, etc., that are liable to bacterial contamination.

What preparations of mercury are used about the eye?

The solution of 1 to 1000 of the bichlorid may be used for cleansing the skin of the lids, the lashes, etc. But for in-

stillation into the conjunctiva one-fifth of this strength should not be exceeded; and other preparations are probably always superior. As a cleansing collyrium the following is better:

Mercuric iodid	1
Potassium iodid	5
Distilled water	20,000

This is essentially the solution introduced by Panas, and known by his name. It may be used instead of the bichlorid solutions, or to wash out the anterior chamber in hypopyon or after a penetrating wound.

The ointment of the *yellow oxid of mercury* is employed as an application to the lids in marginal blepharitis, chronic conjunctivitis, phlyctenular disease, and corneal opacities. It may be half this strength, but a common formula is:

Precipitated mercuric oxid (yellow oxid of mercury)	1
Soft petrolatum, or similar preparation	60

It should be applied daily, placing a mass the size of a grain of rice on the inner surface of the lower lid, closing the lids, and gently rubbing them for a minute or two to diffuse it throughout the conjunctival sac. Ointments of three or more times this strength may be found beneficial, but in some cases cause severe irritation, so that it is best to try first the strength mentioned. The official ointment of the U. S. P. is too strong, 10 per cent.

What preparations of silver are of value in treating eye-diseases?

Silver nitrate is a valuable antiseptic and astringent:

Silver nitrate	1
Distilled water	100

This is to be applied to the inner surface of the lids in acute conjunctivitis once daily. The freedom with which it is applied is to be graduated to the amount of mucopurulent discharge. A solution of double the above strength may be used when there is a large amount of purulent discharge, or

to drop into the eyes of the newborn infant when there is reason to fear ophthalmia neonatorum; and still stronger solutions may be employed in purulent conjunctivitis. Care must be taken not to apply these solutions too frequently. Once a day is often enough, and if there is any evidence of hemorrhage into or from the conjunctiva, or any plastic exudate upon it, they should be used less frequently.

Protargol may be prescribed as a collyrium, thus:

Protargol	2
Distilled water	100

This solution may also be used to wash out the lacrimal passages, or stronger solutions may be employed for this purpose.

For application to the everted lids,

Protargol	20
Distilled water	80

may be employed. With most persons it causes very little irritation; but a few find it extremely irritating. *Argyrol* is the least irritating of the newer silver salts. It is an efficient germicide, and it may be used in solutions twice as strong as those above indicated for protargol.

How is copper sulphate used on the conjunctiva?

Copper sulphate is employed in the form of the pure crystal ground and shaped into a smooth pencil, for application to granular lids, and as a caustic to the interior of chalazia, etc. The crystal should be dry when applied, and a light application can be made by passing quickly over the part, a more severe one by leaving it longer in contact with the tissue.

What preparation of tannin is commonly employed in the eye?

Tannin is used in the official glycerole or in the following form, half the official strength:

Tannin	1
Glycerin	8

This is applied freely to the everted lids, once daily or at longer intervals, for trachoma or chronic catarrhal conjuncti-

vitis. Probably the glycerin should be credited with a considerable share of the beneficial influence.

How is zinc sulphate used in the eye?

Zinc sulphate is used in solution, dropped in the eye one to three times a day, for conjunctivitis caused by the diplobacillus:

Zinc sulphate	2
Distilled water	100

How is alum used?

Alum may be used in crystal, like sulphate of copper, than which it is much milder, or in a solution,

Alum	1
Distilled water	30

which may be dropped in the eye three times daily or oftener.

How is iodin used in the conjunctiva?

Best a 1 per cent. solution of iodin in liquid petrolatum (or a solution of the same strength in glycerin) is applied to the everted lids in the treatment of trachoma. The application may be repeated daily, or every second or third day.

What is jequirity?

The bean of the *Abrus precatorius*, used to improve the condition of the lids in trachoma by exciting an acute inflammation. The lids are either painted with a 2 per cent. infusion, or dusted with the bean reduced to an impalpable powder. Great care must be observed not to excite a too violent inflammation, which might destroy the eye. *Jequiritol* is a series of standardized solutions of the active principle of jequirity. *Jequirity serum* is a partial antidote able to moderate some of the symptoms produced by jequirity.

How is cocain to be used in the eye?

A solution of

Cocain hydrochlorate	1
Distilled water	25

is most generally useful. To secure anesthesia for an operation involving incision of the cornea, one or two drops are to be placed on the part to be operated on, and the application repeated in a couple of minutes. Five minutes later the part is in the best condition for operation. If the operation is a tenotomy for strabismus, the removal of a pterygium, or the opening of a chalazion, a more complete anesthesia from the drug may be obtained by placing crystals of cocain immediately upon the surface to be operated on. The solution should first be instilled once or twice to prevent the smarting the crystals would otherwise cause. When the operation involves the iris, a drop may be placed in the anterior chamber after the completion of the corneal incision. Especial care must be taken to have the solution so used absolutely free from foreign matter. When the operation is to be done on the skin of the lids, the surface should be soaked with the solution for a half-hour prior to the operation. When cocain is used to dilate the pupil, a half-hour or more must elapse before its full effect will be produced. Cocain should not be prescribed in collyria except in very weak solution, ¼ per cent. or less.

When and how should holocain be used in the eye?

On account of its decided antiseptic power, it is much to be preferred to cocain to produce anesthesia for the removal of foreign bodies from the cornea or conjunctiva. The solution

Holocain hydrochlorate	1
Distilled water	100

produces satisfactory local anesthesia, which comes on a little more quickly than that from cocain, and is of slightly shorter duration. It causes no subsequent dilatation of the pupil, and no drying of the cornea or disturbance of the corneal nutrition. The same solution may be used as a collyrium in corneal ulcers, or to relieve the pain of acute conjunctivitis. This drug may be used either alone or in weaker solution with boric acid.

How is atropin used in the eye?

Atropin may be used in the following solution:

Atropin sulphate	1
Distilled water	60

One drop of which is to be placed on the cornea every ten minutes, to secure dilatation of the pupil in iritis; these applications should be continued until dilatation occurs, or the continuance of them for a half-hour or more shows it is not possible to produce it. Such free use of the drug is liable to produce symptoms of atropin-poisoning (see page 125). After dilatation is obtained they may be made every two or three hours to sustain it.

To paralyze the accommodation, as for the measurement of ametropia, and to secure a prolonged rest for the ametropic eye; or for corneal ulcer threatening central perforation—

Atropin sulphate	1
Distilled water	120

is to be instilled, one drop at a time, three times a day. Two weeks are required for the eye to completely recover from the effects of such a solution.

To dilate the pupil in partial cataract—

Atropin sulphate	1
Distilled water	5000

one drop to be instilled every day or two.

How are daturin, duboisin, and hyoscyamin used in the eye?

Daturin, *duboisin*, and *hyoscyamin* are to be used alike, being practically identical. In general their solutions require to be about half the strength of those of atropin. To produce paralysis of the accommodation—

Hyoscyamin hydrobromate	1
Distilled water	240

may be instilled, one drop three times daily. It requires about one week for the eye to recover from such a solution.

How is scopolamin used in the eye?

Scopolamin has practically the same action as the above, and may be used in the same way. It is also sometimes used thus:

Scopolamin hydrobromate	1
Distilled water	1000

one drop in the eye every ten minutes for a half-hour to produce rapid paralysis of accommodation.

How is homatropin used in the eye?

Homatropin, on account of its brief period of influence, is the best cycloplegic for purposes of diagnosis. It is used in

Homatropin hydrobromate	1
Distilled water	40

one drop of this to be placed on the upper part of the cornea every ten minutes for a half-hour or more, and the refraction determined a half-hour later. After this, recovery is complete in two days. A solution one-tenth the strength of the above is sufficient for dilatation of the pupil.

How is euphthalmin used in the eye?

As a brief mydriatic. It has little effect upon the accommodation, and recovery from it is nearly complete in a few hours.

Euphthalmin	5
Distilled water	100

makes a solution which dilates the pupil widely, even in the presence of a strong light, for an hour or so. As the drug is somewhat expensive, the following solution will be found much cheaper, and is about as useful:

Euphthalmin	1
Cocain hydrochlorate	1
Trikresol solution (1 to 1000)	100

What are the myotics, and how are they used?

Eserin or *physostigmin* is employed, as in

Physostigmin sulphate	1
Distilled water	1000

one drop instilled into the conjunctival sac, to prevent prolapse of the iris after simple extraction of cataract, or to contract the pupil in acute glaucoma. If, in the latter case, this solution fails to cause contraction of the pupil, stronger solutions may be employed, even up to 1 or 2 per cent.

In simple corneal ulcer, mydriasis, etc., solutions from one-half to one-tenth the above strength are employed.

Pilocarpin is a considerably weaker myotic than the foregoing. It is used as

Pilocarpin nitrate	1
Distilled water	200

two or three drops in the eye at bedtime, for asthenopia not dependent on ametropia or muscular derangement; or twice a day, to contract the pupil, in cortical cataract.

How are boric acid and borax used in the eye?

Boric acid and *borax* are both soothing and cleansing. They may be used as

Boric acid	3
Sodium biborate	1
Distilled water	100

five or ten drops of which may be instilled three times a day or oftener. Or the same proportion of either of the drugs alone may be used in the same way. Boric acid in impalpable powder may be dusted into the conjunctiva to produce a mild irritant action. *Boroglycerid*, the 50 per cent. solution of boric acid in glycerin, may be applied to the everted lids for trachoma or chronic catarrhal conjunctivitis.

What are the uses of the physiologic salt solution?

For cleansing the eye, as a soothing application or as a placebo, or to wash out the anterior chamber or to fill up the eye after collapse from escape of a part of its contents. The following:

Sodium chlorid	1
Distilled water and camphor water, each	100

is to be used as the boric-acid solutions.

How is potassium permanganate employed?

It is used freely as a solution, 1 : 3000 in distilled water, to cleanse the eye in purulent conjunctivitis and trachoma : or in 10 per cent. solution applied to the everted lids.

How is adrenal extract used in the eye?

A freshly made and filtered 2 per cent. solution may be dropped into the conjunctiva, or injected into the lacrimal sac, to reduce hyperemia or prevent hemorrhage during an operation. The solution of *adrenalin chlorid*, 1 : 1000, and similar preparations sold under other names, are convenient methods of applying the active principle of the gland.

How is fluorescin used in the eye?

The following solution,

Fluorescin	1
Sodium bicarbonate	2
Distilled water	100

is dropped upon the cornea to detect the extent of a corneal ulcer. It quickly colors green the area which has lost its epithelium.

What antiseptic dusting-powders are used in the eye?

Calomel is employed as a mild irritant, somewhat similar to *boric acid*. It is commonly dusted upon the cornea to promote the absorption of corneal opacities. *Iodoform* is dusted into the eye to promote the healing of operative or other wounds. *Aristol* and *acetanilid*, either alone or mixed with an equal quantity of boric acid, may be used for the same purpose. Only impalpable powders should be employed.

What is dionin, and how is it used?

Dionin (ethyl morphine hydrochlorate) is an ocular lymphagogue and analgesic. A small portion of the powdered drug may be placed on the conjunctiva, or a 10 per cent. solution instilled, to relieve the pain of burns, iritis, glaucoma, etc. It is not an anesthetic, but may give relief from pain for many hours. It produces great enlargement of the blood-vessels and lymph channels of the part, and is used to aid in the removal of opacities in the cornea or vitreous. In chronic cases it may be used in solution (½ to 1 per cent.), two or three drops instilled daily, or at longer intervals.

INJURIES TO THE EYE AND ORBIT.

CONTUSIONS.

What injuries are produced by bruises of the eyeball?

Rupture of the sclera; rupture of the iris; dislocation of the crystalline lens; intra-ocular hemorrhage; edema of the retina and choroid; detachment of the retina and rupture of the choroid.

What is rupture of the sclera?

It is caused by a heavy blow on the eyeball; most frequently from the fist. In most cases the rupture runs parallel with the upper corneal margin, and 3 to 5 mm. back from it. Through the tear in the sclera the crystalline lens and often a part or the whole of the iris may be forced out. Often no break occurs in the conjunctiva, and the lens is found lying beneath it. The hemorrhage within the eyeball at first conceals the absence of the lens and iris from their normal position.

What should be done for rupture of the sclera?

If seen early the lens and prolapsed iris should be removed from beneath the conjunctiva, and the edges of the scleral tear brought together with one or more sutures. Iced cloths should be applied continuously for the first day or two, and the eye kept under atropin until free from inflammation. It may possibly recover some useful vision.

What are the signs of rupture of the iris?

If the iris is torn loose from its ciliary attachment, *iridodialysis*, the pupil on that side appears flattened (see Fig. 72). If ruptures involve the sphincter, the pupil will be partly

dilated and its margin irregularly notched. Sometimes the rupture causes a separation of the radiating fibers, in which case it may at first be evidenced only by bleeding into the anterior chamber. When the blood has been absorbed, red fundus reflex may be seen with the ophthalmoscope through the opening in the iris, whatever its situation. Sometimes, following injury to the eyeball, absorption of pigment from the posterior layer of the iris occurs, allowing the fundus

FIG. 72.—Iridodialysis (after Swanzy).

reflex to be seen through the meshes of the iris stroma. Sometimes the iris injury is indicated only by weakness of the sphincter, allowing partial dilatation of the pupil.

What is the treatment for rupture of the iris?

Cold applications at first to keep down inflammatory reaction; the use of atropin to keep the iris at rest until healing has occurred, and sometimes the subsequent use of a miotic to help restore the activity of the sphincter.

What are the signs of complete dislocation of the lens?

The anterior chamber is deep and the iris tremulous, showing a wavy movement upon any motion of the eye. With the ophthalmoscope the lens, usually more or less hazy or opaque, may be seen lying back of the iris, commonly below. Sometimes the lens is dislocated forward into the anterior chamber, where it may be seen in front of the iris and pupil, and where it is certain to cause acute glaucoma.

How is incomplete luxation of the lens recognized?

The anterior chamber will be found deeper at one part than on the opposite side. The oblique position of the lens

may cause astigmatism and myopia not before present. It may set up a secondary glaucoma.

What should be done for dislocated lens?

The eyes should be kept quiet until the irritation due to injury has passed. Prolonged rest under a mydriatic may secure restoration when the luxation is partial, but a mydriatic must be used with caution; the great danger from such injuries being secondary glaucoma. A completely dislocated lens should be removed. After partial dislocation, it may be necessary to use eserin or to do an iridectomy.

What are the slighter injuries to the retina and choroid.

Blows from small objects, as a whiplash or champagne-cork, sometimes cause great dimness of vision, which is not, however, permanent. The ophthalmoscope shows at the back part of the eye the retina, gray, hazy, and swollen from edema (*commotio retinæ*). This condition passes away in a few days. Patches of light yellowish choroidal swelling may then appear, or these may show through the swollen retina. They entirely disappear a few days later, or leave only a slight disturbance of the choroidal pigment. Such lesions are commonly seated about the posterior pole of the eye.

How should such injuries be treated?

The eye should be kept at rest under a mydriatic, and the patient kept quiet until the vision, with correcting lenses, has again become normal.

How is traumatic detachment of the retina known and treated?

It may be suspected when loss of a part of the field of vision follows a bruise of the eyeball, but it can only be certainly known by seeing the detached retina with the ophthalmoscope. It may occur immediately, or be discovered when the accompanying hemorrhage into the vitreous has cleared up; or it may come on several days or weeks after the injury. It is to be treated like spontaneous detachment of the retina. It offers a somewhat better prospect of permanent recovery than does detachment from other causes.

What is rupture of the choroid?

After severe bruises of the eyeball, with intra-ocular hemorrhage, which at first hides the fundus, there is sometimes found a crescentic patch of white, more or less concentric with the optic disk. This is called a choroidal rupture (see Fig. 73), but probably it is at least partly due

FIG. 73.—Rupture of the choroid.

to atrophy of injured tissue, rather than simply to a tear in the choroid. It is accompanied with permanent impairment of vision, and is not amenable to treatment.

How may blows on the head cause blindness?

Fracture of the base of the skull, when due to blows on the forehead or temple, is very apt to extend into the optic foramen, causing injury to the optic nerve and subsequent blindness. Hemorrhage causing pressure upon the nerve may possibly cause blindness when there has been no fracture. The loss of sight may be noticed immediately, or upon regain-

ing consciousness. Or it may be discovered only after several hours or days. It usually becomes complete and permanent. At first no ophthalmoscopic changes are found, but after some weeks optic atrophy becomes evident.

What is the significance of ecchymosis of the lids?

When due to injury of the soft parts, swelling is noticed immediately and the discoloration begins at the point of injury. It may also be due to fracture of some portion of the orbital walls. In that case there may be no swelling, and the discoloration appears only after many hours or days. Then it is first noticed on the skin just within the margin of the orbit, or through the conjunctiva at the retrotarsal folds.

What is the treatment for ecchymosis of the lids?

Immediately after the injury firm uniform pressure should be applied. An ice-compress may be used for this purpose if available. Raw beef or white of egg makes a good early application. Later, pressure, massage, and hot fomentations are to be used.

How do dislocations of the eyeball occur.

The eyeball may be torn completely from its socket by the horn of a cow or the finger of an assailant. It may be displaced forward (*exophthalmos*) by a thrusting in of some part of the wall of the orbit. It may sink in the orbit (*enophthalmos*) because of damage to the tissues behind it, fracture of the orbital walls, or relaxation of the orbital ligaments, which hold the eye in position.

PENETRATING WOUNDS OF THE EYEBALL.

What should be done for wounds of the conjunctiva?

They should be thoroughly cleansed and the parts brought into good position and, if necessary, retained by one or more sutures. Then the eyes should be kept cleansed and quiet for several days until correct union can occur.

How are injuries of the cornea detected?

By inspection, under oblique illumination, any opacity is

revealed; and by examining the reflection from a window or a strongly illuminated white card held near the eyes, any irregularity of the surface may be discovered. Fluorescin solution causes a greenish discoloration of the part of the cornea from which the epithelium has been removed. Even slight abrasions of the cornea may be very painful. Corneal injuries are especially liable to lead to infection.

What is the treatment for such injuries?

Careful cleansing, protection from dust and other irritants by a light dressing, and the instillation of a mydriatic. Use of the eyes should be avoided as much as possible until the process of repair is well started.

How do we know when a wound has penetrated the sclero-corneal coat?

By loss of the normal intra-ocular tension (softening of the eyeball), which continues until after the wound is entirely closed, and by evidences of injury of the deeper parts of the eye. There may be apparent loss of substance or prolapse of the iris, opacity in the lens, or wounds of the choroid only visible with the ophthalmoscope. Hemorrhage within the eyeball may at first conceal these signs, but hemorrhage within the eye may arise from bruise without penetration of the coats.

What should be done for a penetrating wound?

It should be thoroughly cleansed, even though this involve considerable disturbance of it and free bleeding. All badly damaged tissue should be removed. The lips of the wound must be brought into proper apposition, and retained by sutures if necessary. Atropin should be instilled, and iced cloths applied for one or two days, until danger of severe reaction is past. The eye is then to be kept covered with a light dressing, and the patient kept from violent exercise, and usually upon a low diet. Properly treated, recovery with useful vision is possible for eyes that have been very severely wounded.

What should be done if the iris is prolapsed?

If the wound is quite recent and comparatively small, and

if it seems to be entirely aseptic, an attempt may be made to return the iris and to retain it in normal position by instilling eserin. Such attempts are rarely successful. Usually it is best to cut off the protruding portion, having first, by traction, loosened the iris from any attachment it may be forming to the edge of the wound. If more than one day has elapsed, it may be best to defer the removal for a week or two until the violence of the inflammation has passed. If the prolapse be small and situated toward the periphery, it may be best not to disturb it at all unless it seems inclined to extend, or the eye tends to continue red and irritable.

How is a wound of the lens recognized?

By opacity, which begins at the point of injury and extends throughout the lens, and by swelling of the lens proportioned to the extent of its injury. The opacity often spreads most rapidly toward the posterior pole of the lens, and from that region to other parts. The swelling is greatest about the point of injury, and fragments of the lens substance may be pushed into the anterior chamber.

What is the treatment for wound of the lens?

If the opening in the lens capsule be very small, there is a possibility of its healing. This may be followed by arrest of the opacity, or even subsequent clearing up. To favor such a result the eye should be kept absolutely at rest, under atropin, for many weeks, even though it may be quite free from hyperemia. If the opacity increases slowly, with little swelling of the lens, the eye should be kept under observation, and atropin used if signs of irritation develop. When the lens has become fully opaque, it should be removed by a cataract operation appropriate to the age of the patient. If there be great swelling of the injured lens, it should be removed at once—at least the bulk of it—to prevent injury of other portions of the eye from secondary glaucoma.

What should be done for wounds of the ciliary region?

Since these often involve injury of the lens in a part where the resulting opacity cannot at first be seen, pushing forward of the iris by lens swelling must be carefully looked for. If

it appear, the removal of the lens, usually with iridectomy, should be resorted to. The damaged tissue of the ciliary body, being almost invariably pushed into the wound, should be carefully removed, even though some extension of the external opening be required to accomplish it. Wounds of this region have been especially credited with causing sympathetic ophthalmia.

FOREIGN BODIES IN THE EYE.

How do we look for foreign bodies in the conjunctiva?

Place the patient in a good light. First examine the exposed portions of the eyeball. Then have the patient look upward, while the lower lid is drawn down, and search the lower cul-de-sac, especially the folds near the caruncle. Next, while the patient looks down, evert the upper lid, and examine the portion thus exposed. Finally, while the eye is turned strongly downward, draw the lid away from the eyeball and examine the upper cul-de-sac. In the large majority of cases the foreign body will be found resting about the middle of the everted upper lid.

How is a foreign body removed from the conjunctiva?

A local anesthetic, preferably holocain, should be instilled. This may be done before making the search for the foreign body. When the offending substance lies on the surface of the conjunctiva, it should be wiped away with a little absorbent cotton wrapped firmly on a probe or match-stick. If the particle be imbedded in the conjunctiva, an effort may be made to turn it out with the spud used to remove foreign bodies from the cornea, but sometimes it will be better to seize the foreign body with fine forceps and, drawing upon it, snip away with scissors the conjunctiva that holds it.

How do we search for a foreign body in the cornea?

If there is much photophobia or irritation, begin by instilling a local anesthetic, preferably holocain. Place the patient facing a window that gives unobstructed skylight, and examine carefully the reflection of this light from the cornea. The presence of any irregularity will be shown by

a break in this reflection. If the foreign body be small, however, it may be concealed in the layer of mucus and tears covering the surface. Dry the surface with a pledget of absorbent cotton. If the foreign body has been imbedded for several hours or days some pericorneal redness may be noticed. This is most marked at the part of the corneal margin nearest the foreign body. If the zone be equal all around the cornea, the foreign body will be found near the center. Sometimes the location of the corneal injury is best brought out by instilling the solution of fluorescin. If daylight be not available or if it fails to reveal the foreign body, examine the cornea by oblique illumination and with a strong magnifier. Make the examination from different directions. A light foreign body is best seen against the black pupil. One of dark color may be most evident with a background of light iris. Minute particles are sometimes best seen against the red fundus reflex by dilating the pupil and using the ophthalmoscope, with its strongest convex lens, to inspect the cornea. The sensation of a foreign body in the eye cannot be relied on for diagnosis. The same sensation is produced by any inflammatory roughening of the conjunctiva. On the other hand, a foreign body imbedded deeply enough in the cornea to not scratch the lid may produce no sensation, until after some days an inflammation arises that may be ascribed to some wholly different cause.

What is the treatment for a foreign body in the cornea?

The prompt removal of the foreign body, with care to leave the wound aseptic. An exception to this must be made when great numbers of minute particles of sand have been driven into the cornea by an explosion. In such cases, if it is impossible to remove all these foreign bodies without total destruction of the cornea, the larger and more superficial particles should be removed; and the eye must be placed under the influence of atropin and kept at rest for a long period.

How should an ordinary foreign body be removed from the cornea?

The eye being under the influence of a local anesthetic

(holocain), and placed so as to get the best illumination upon it; the spud (see Fig. 74) is to be placed alongside of the foreign body and pushed in between it and the corneal tissue.

FIG. 74.—Spud for removing foreign bodies from the cornea.

In this way, by a wedge-like action, the foreign body is loosened and forced from its bed in the cornea. After the principal mass has thus been removed, very careful search should be made for any remaining particles, and the tissue that has been in contact with the foreign body should be carefully scraped. But there should be no scraping of the epithelium from the neighboring parts of the corneal surface. The removal of such foreign bodies is best done with the aid of the binocular magnifier (see Fig. 75). Particles of iron

FIG. 75.—Binocular magnifier supported by a spring steel headband, for examination of the eye and the performance of certain operations.

may be removed with a strong magnet. In all cases it is especially important to thoroughly cleanse the resulting wound.

How should powder-grains be removed from the cornea?

Since an unburned grain of gunpowder quickly becomes disintegrated on exposure to the corneal fluid, it cannot be picked out as a whole. It should be touched with the actual cautery, preferably the galvanocautery. This destroys the tissue in which the finely divided charcoal of the powder is

becoming diffused, and the resulting slough carries the foreign material with it, with the minimum danger of infection.

How should a beard of grain or similar body be removed?

Beards of grain, and of some species of grass, the spines of chestnut-burrs, and the hairs of caterpillars, on account of their shape, and the depth to which they often penetrate, cannot be removed by the methods above given. If the foreign body protrude sufficiently, it may be grasped by fine forceps or tweezers, having jaws like those of the forceps for removing diseased lashes (see Fig. 76). The attempt to re-

FIG. 76.—Forceps for removing misplaced lashes or beards of grain from the cornea.

move such a foreign body, however, will often break it off; and the part remaining will have to be dug out with a fine pointed knife or corneal needle. It will often be well to loosen the foreign body somewhat, and gain the chance of a better hold upon it by partly digging it out before attempting to pull it. Sometimes it is necessary to actually remove the corneal tissue in which the foreign body is imbedded; and spines of the chestnut-burr have been removed by introducing the forceps into the anterior chamber and pulling them through on that side.

How can one remove a foreign body that projects into the anterior chamber?

In this case there is great danger that in attempting removal the aqueous will escape and the lens or iris be injured

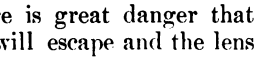

FIG. 77.—Broad needle.

by contact with the foreign body. It is sometimes best to allow the eye to remain perfectly quiet for a few hours until

the swelling of the tissue stops the leaking from the anterior chamber and re-establishes its full depth. Then a broad needle (Fig. 77) should be introduced through a sound portion of the cornea and passed behind the foreign body, so as to just press against it, and the point of the needle imbedded in the inner surface of the cornea to steady it. The foreign body is then to be loosened with a spud or needle and removed; the broad needle protecting the lens and iris from injury.

What are the appearances when a foreign body is long retained in the cornea?

A single foreign body of considerable size may remain a long time in the cornea without causing serious disturbance. If deeply imbedded it becomes hidden in a zone of gray tissue that encysts it. If superficial, it is buried by whitish masses of epithelium that form around it, and presents somewhat the appearance of an opaque corneal scar. Such foreign bodies should be removed, for even if the eye gets quiet for a time, they ultimately cause trouble.

What are the signs of a foreign body in the iris?

A wound penetrating the anterior chamber, causing diminished intra-ocular tension; sometimes bleeding that may conceal the foreign body; and the appearance of the foreign body upon or in the iris. Very careful search with focal illumination and a magnifier may be required to detect the foreign body.

What should be done for a foreign body in the iris?

An incision is to be made near the periphery of the cornea. If the foreign body is probably aseptic, an attempt may be made to remove it, leaving the iris intact. In most cases this will not succeed; and if there is a probability of infection the attempt should not be made. In either case the foreign body should be seized with the forceps and drawn out, bringing with it the adjoining iris. A part of the iris as small as will include all damaged tissue, with the foreign body, must be cut off with the iris-scissors. The remainder of the iris is then to be returned to its normal position, and the eye treated

as after iridectomy. Particles of iron, if aseptic, may be removed by the electromagnet. Foreign bodies have been retained in the iris for long periods, but they menace the safety of the eye, and it is always better to remove them. An exception to this rule may be made in regard to powder-grains that have ceased to cause irritation.

What are the symptoms of a foreign body in the lens?

At first it may be clearly seen lying in the lens substance, if not hidden by hemorrhage in the anterior chamber. But later, sometimes in a few hours, it becomes veiled by the haziness of the lens surrounding it, which gradually extends to all portions of the lens, forming a traumatic cataract. Swelling of the lens also occurs, proportioned to the size of the opening in the capsule.

What should be done for a foreign body in the lens?

If the lens swelling be slight, the eye should merely be placed under a mydriatic until the cataract has become complete. Then the lens should be extracted, care being taken to make a free corneal incision, so as to bring out the cataract with the foreign body included in it. When the foreign body is known to be a bit of iron or steel, it may, in a young person, be extracted with the electromagnet, and the fluid cataract removed through a small incision or by suction, or needled for absorption.

When should we suspect the lodgement of a foreign body deep in the eye?

In every case of penetrating wound of the eyeball that is not known to have been made by a clean blade or point, which would leave nothing behind it in the wound. If a wound of the eye by some flying substance causes loss of the normal tension of the eyeball and injury to parts included within the sclera, there is a strong presumption that the wounding body has remained within the eye.

How should one seek a foreign body in the vitreous?

At the earliest possible moment an ophthalmoscopic examination should be made through the dilated pupil. This may reveal the foreign body, its exact nature, and location; or it

may reveal a track, marked with blood, across the vitreous, showing the direction in which the foreign body has passed.

Again, in rare cases, it may show a wound of exit through which the foreign body has passed to a less dangerous resting-place in the orbit. In a few hours the vitreous may become so generally clouded, through diffusion of the intraocular hemorrhage or inflammatory change, that it will be quite impossible to obtain any such definite information with the ophthalmoscope.

What is the use of the X-ray in these cases?

When the foreign body can no longer be seen, it becomes a most important means of diagnosis. With the fluoroscope

FIG. 78.—Sweet's apparatus for X-ray diagnosis of foreign bodies.

only foreign bodies of exceptionally large size can be recognized in the eyeball. In most cases a radiograph must be made. The plate should be bound to the temple on the side of the injured eye. The patient should lie down so that

he can remain perfectly still. A good tube, with a current giving it a high penetrating power, should be placed on the side opposite the injured eye, and a little in advance of the face. A good radiogram, taken under these conditions, will reveal almost any foreign body that is one millimeter or more in diameter. By use of a special apparatus, shown in Fig. 78, or by fastening to the margins of the orbit bits of thick lead wire to serve as reference points, and taking two radiograms with the tubes placed in different positions, the location of the foreign body within the eyeball can be determined quite accurately.

How may the electromagnet be used in the diagnosis of particles of steel within the eyeball?

The injured eye may be brought within a few inches of the giant (Haab) magnet, then when the current is turned on the attraction of the particle in the eye causes a sudden pain. If, at the first trial, no pain is felt, the eye may be brought somewhat closer and the test repeated. The large portable magnet (Fig. 79) may be used by bringing its tip toward the eye, first from one direction and then from another. By the distance at which pain is first felt, as it approaches from different directions, one may be able to judge of the part of the eyeball in which the bit of steel or iron is located. It is possible, however, for the foreign body to be so placed that no pain can be elicited with a magnet.

What is the sideroscope?

It is a steel needle, four or five inches long, suspended in a horizontal position by a single strand of raw silk and carefully protected from movement by the air. This needle is strongly magnetized and placed in its position of rest, pointing north and south. The injured eye is brought close to one end of this delicate magnet. If it contain a particle of steel or iron, the needle will be attracted by it and deviate from its former position. A small mirror is fastened to the center of the needle and a ray of light reflected from this mirror reveals the slightest change of direction. By such an instrument the presence of even the smallest particle of steel that can penetrate to the interior of the eye may be revealed. By placing t

instrument on a very firm foundation, where there will be no jarring from street traffic, and no influence from electric currents or neighboring masses of iron or steel, and by making repeated observations, it is also possible to determine with it the position of the foreign body in the eye.

What is the treatment for a foreign body in the posterior portion of the eyeball?

Remove it as soon as possible. The only exception to this will be in the case of a small foreign body in an eye that has become entirely quiet. Such an eye, while not free from ultimate risk, may go for many years without suffering any symptoms from the presence of the foreign body; and its removal should only be undertaken when the patient understands the respective risks and consents that it be done. In all cases except these, the probability of loss of the injured eye, and the risk of sympathetic disease of the other are so great, that immediate removal should be insisted upon; and further responsibility in the case may properly be declined if this is refused.

How should a bit of iron or steel be removed?

With the electromagnet. The most useful and reliable form being the large portable magnet, operated with the 110-volt direct current (see Fig. 79). The magnet must be a

FIG. 79.—Johnson's portable electromagnet.

powerful one and in good order. If feeble it will often prove insufficient to dislodge the foreign body; and will merely mislead the patient and the surgeon into a belief that a proper attempt has been made, when such is not the case. The eye should be thoroughly cleansed and an open-

ing made in the sclera large enough to admit the magnet-tip, and to allow the free passage of the foreign body, without danger of scraping from it the septic material or damaged tissue that may surround it. The opening in the sclera may be either the wound of entrance enlarged, or an antero-posterior incision made close to the supposed location of the foreign body. The magnet-tip is sterilized and introduced into this incision. It is best to begin with the short tip, which will exert a stronger traction without being introduced within the eyeball. Often the bit of steel may be heard to strike the tip, which is then withdrawn. Any tissue that appears closely adherent to the foreign body should be cut off and removed with it. If the short tip fails to secure the foreign body, it may be replaced with a longer one that can be thrust farther into the eye. After the removal of the foreign body, the opening in the sclera should be closed, if necessary, by a suture, and the eye treated as after a severe penetrating wound.

What should be done for other foreign bodies in the back part of the eye?

Unless very small and imbedded for some time, and causing no irritation, their position should, if possible, be accurately determined by the ophthalmoscope or X-rays; and they should be removed with forceps through the enlarged wound of entrance or an incision made for the purpose. Since nearly all eyes containing such foreign bodies become absolutely blind, and threaten the sight of the other eye, it is right to attempt removal, even when there is great doubt of the success of such an attempt. If the removal can be accomplished, even at the expense of considerable mutilation of the globe, it must be regarded as a great gain.

What is to be done if the foreign body cannot be removed?

If the presence of a foreign body is certainly established, it is often best to remove the eye or to eviscerate it at once. If useful sight remain, removal must be deferred until resulting inflammation has made it certain that this will be lost. If the patient can remain under observation, and is willing to take the risk, the eye may be allowed to remain until renewed

inflammation in it, or symptoms of disturbance in the sound eye, render removal imperative.

When the attempt to extract a foreign body is to be made under general anesthesia, it is often wise to obtain the patient's previous consent to the immediate removal of the eyeball in case of failure to get the foreign body. The dangers to be guarded against by early removal of the eyeball are prolonged disability from chronic inflammation, that is liable to recur at a later period, and from sympathetic disease of the other eye.

What is the prognosis if the foreign body is successfully removed?

In a few cases useful vision is retained permanently. In a majority of cases, a sightless but quiet and comparatively safe eyeball is secured. But in some cases it becomes necessary subsequently to remove the eye to prevent sympathetic disease of the other. The degree of permanent success attained probably depends quite as much upon the complete removal of injured and infected tissue around it as upon the removal of the foreign body itself.

What are the characteristics of penetrating wounds of the orbit?

They are likely to be deeper and more serious than appears upon superficial inspection. The outside tissue is soft, so that when the lids have been penetrated little resistance is encountered until the bony wall of the orbit is reached. The vascularity of the superficial tissues causes a speedy, partial or complete closure of the wound near the surface, so that even on probing the injury may appear quite superficial. Sometimes injury of a blood-vessel will, by hemorrhage, cause swelling and exophthalmos, or lesion of a nerve or muscle may produce a corresponding paralysis.

What are the character and significance of emphysema of the orbit?

It is shown by a soft, crackling, pale swelling of all adjoining parts, which increases rapidly, especially on blowing the nose. It also quickly subsides when the escape of air into the tissue is stopped. Its occurrence indicates a wound pene-

trating one of the air sinuses adjoining the orbit, or a fracture of the orbital wall into one of these sinuses. The escape of air into the tissues commonly ceases in a few hours because of the obstruction produced by inflammatory swelling.

How is a foreign body in the orbit recognized and treated?

Thorough probing immediately after its entrance, with careful exploration of all parts of the wound, will usually guard against the mistake of overlooking its presence; but if the case be not thoroughly examined shortly after the injury swelling of the parts supervenes, and the presence of even a large foreign body readily escapes notice. A discharging sinus or continued inflammatory swelling should always cause the suspicion that a foreign body may be present; and to determine if this really is the case an appropriate incision should be made, and the orbit explored with the finger. In all obscure cases, too, the X-rays should be employed in much the same way as for foreign bodies in the eyeball. The treatment includes prompt removal of the foreign body, cleansing of the tract of the wound, and often gauze drainage for a day or two. The superficial wound must be brought into the best apposition, and retained there by sutures if necessary. Drains and sutures should be removed early to avoid unnecessary scar-tissue.

BURNS AND INJURIES BY CAUSTICS.

How do burns of the eyeball occur?

By explosions, causing the sudden escape of steam, or scattering boiling water, or drops of molten metal, or sudden exposure to flame. Burns from other causes will usually affect the lids.

What are the symptoms of burn of the cornea?

The coagulation of the affected layers causes an opaque white appearance even when the injury is quite superficial. This opacity may be very marked, giving the impression of complete destruction of the membrane. The upper and lower margins of the cornea often escape injury, and from these parts it may be possible to judge the depth to which the cornea is affected. Usually the injury is quite superficial, and

with the separation of the coagulated tissue, the eye may pass in a few days from an appearance of complete blindness to almost normal. Unless the injury is quite superficial it will cause pericorneal redness. Injuries of this kind are not usually as painful as superficial abrasions of the cornea.

What are the symptoms of burn of the conjunctiva?

It may show a superficial layer of gray, from heat-coagulation, or a deeper dense white slough, if the burn be more severe. The other portions of the conjunctiva immediately become hyperemic and somewhat swollen; the redness being most intense near the margin on the slough.

What is the great danger from burn of the eyeball?

Adhesions between the globe and surface of the lids, which tend to contract, preventing the full usefulness of the eye and rendering it unsightly (see Symblepharon, page 83).

How should burn of the eyeball be treated?

If due to hot metal, this must be carefully removed. The eye should be cleansed, petrolatum or some such preparation should be instilled to protect the injured surface. Atropin must be used if the cornea is much involved. The eye should be kept quiet under a light dressing, and only disturbed as often as may be necessary for the removal of any discharge. If the raw surface left by the burn extends both upon the eyeball and lid, or if it involves much of the bulbar conjunctiva, it should be covered by epithelial grafts, either from the skin or, better, from the inner surface of the lower lip. The wearing of a plate of lead, or layers of rubber, to separate raw surfaces until covered with epithelium, may prevent adhesions that would otherwise form; but it will not control the contraction of cicatricial bands that have already formed.

What is the treatment for burns of the lids?

In general, they require the treatment for burns of other portions of the skin surface. But on account of the vascularity of the lids, the processes of repair are usually very rapid; and to preserve the flexibility required for the performance of their function, and to avoid cosmetic deformity, it is important that epithelial grafts be employed to replace

the destroyed portion at a very early date. Subsequently, much may be gained by persistent massage of the scars, but sometimes the earlier treatment will require to be supplemented by one or more plastic operations. These should be done after the parts have attained a comparatively permanent condition.

What are the common injuries to the eye by caustics?

Quicklime gains access to the conjunctiva either as a powder or in a drop of whitewash. Strong acids and alkalies may be thrown into the eye by accident or for the purpose of personal injury.

What are the symptoms of burn by lime?

The lime enters into close combination with the tissue, so that particles of it are almost always found closely adherent to the tissues. There is severe persistent pain, photophobia, and lacrimation. The redness is at first chiefly seen in the part of the conjunctiva directly injured, usually the lower cul-de-sac.

What is the treatment for such an injury?

The first point is the complete removal of all particles of the caustic. To effect this, a local anesthetic should be employed, and it may be necessary to seize particles of the lime with the forceps and snip them out with the scissors. The eye should then be washed out and olive oil or petrolatum freely instilled. The subsequent treatment will be that for a burn of the eyeball.

What is the treatment for injuries by other caustics?

In all cases the immediate washing out of the conjunctiva with water, preferably tepid or slightly warm. For the strong acids, a weak alkali, usually a non-irritating soap or sodium bicarbonate solution, may be added to the water. For alkalies, extremely dilute vinegar may be employed. But these chemical antidotes are only of value if used very quickly; and if they are not immediately at hand, the thorough cleansing with water will render them quite unnecessary. Subsequently, the eye is to be treated as for an ordinary burn, with instillation of some bland oil, protection from outside irritants, and careful removal of any discharg

EYE-SYMPTOMS OF GENERAL DISEASE.

SPECIAL SYMPTOMS.

How are the eye-symptoms of general disease to be looked for?

Inspection of the eyes should be particularly directed to discovering evidences of inflammation or swelling of the adjoining parts, and the size and reactions of the pupils. With the ophthalmoscope evidences of optic neuritis, retinitis, and optic atrophy should be looked for. The ocular movements should be carefully tested. The acuteness of vision should be ascertained, and if this be impaired, the color-perception at the fixation-point carefully determined. The field of vision should be investigated, especially as to narrowing of the color-fields.

What diseases are attended with general hyperemia of the eyes?

All the acute fevers, especially measles and cerebrospinal meningitis.

What may cause swelling about the orbit?

Thrombosis involving the cavernous sinus; rupture of the carotid into this sinus; aneurism of the ophthalmic artery; disease of the sinuses adjoining the orbit; or malignant disease involving the base of the skull.

What is the significance of inequality of the pupils?

It may have existed throughout life as a personal peculiarity. It may be due to adhesions left by a previous iritis. It occurs, as a temporary and variable symptom, in degenerative diseases of the brain and spinal cord. It may indicate partial paralysis of the oculomotor nerve. In connection with acute disease or injury it is usually an indirect or distant

symptom, of comparatively little value because of the large number of conditions that may cause it.

What may dilatation of the pupil signify?

Strong emotional excitement; the influence of a mydriatic; blindness; extreme general anemia; irritative lesions of the upper portions of the spinal cord; destructive lesions of the oculomotor nerve or its nuclei in the medulla. Glaucoma also should be borne in mind in connection with general disease.

What conditions cause myosis?

Contraction of the pupil may attend destructive lesions of the spinal cord; and irritative lesions of the brain and its membranes, as meningitis; apoplexy (early); hyperemia attending acute fevers; chronic tobacco-poisoning; and degenerative disease of the central nervous system. Adhesions from old iritis and the normally small senile pupil must be borne in mind in this connection.

What reactions of the pupil are especially significant?

Its failure to contract to light, although otherwise freely movable—the so-called Argyll-Robertson pupil—and the failure to contract when light is thrown on the blind half of the retina in hemianopsia. (For Pupillary Reactions, see page 130.)

What is indicated by optic neuritis?

Organic disease of the brain or its membranes, as brain-tumors or inflammations. Also syphilis, albuminuria, or lead-poisoning. It is a symptom of little value, as indicating the exact location of the brain-lesion or its especial character. But it is of the highest importance as indicating that the disease is organic and not merely functional. Thus it will sometimes establish a diagnosis between hysteria and brain-tumor.

What is the significance of optic atrophy?

It may be secondary to neuritis, and thus possess all the significance of neuritis. It may be due to chronic poisoning by alcohol or lead; or to syphilis, malaria, or diabetes. It is

sometimes hereditary. It occurs with chronic degenerative disease of the central nervous system, especially sclerosis.

What diseases should be thought of in connection with retinitis?

Septic affections, leukemia, Bright's disease, vascular degenerations, gout, diabetes, and syphilis.

What may be suspected from disturbance of the ocular movements?

Spastic squint suggests hysteria, but may attend or follow the acute fevers. Paralytic squint may follow the specific fevers, especially diphtheria. It also occurs in chronic degenerative disease of the brain and cord. Its most frequent cause is syphilis. But rheumatism, diabetes, malaria, and other chronic diseases may cause it.

What diseases are indicated by narrowing of the field of vision?

All those that cause optic atrophy. The symptom is of especial importance, because it may be well marked, especially the narrowing of the color-fields, before any certain evidence of optic atrophy can be discovered with the ophthalmoscope. Chronic poisoning may cause it.

What causes loss of color-vision at the center of the field?

Central color-scotoma is a symptom of toxic amblyopias caused by tobacco, alcohol, iodoform, the smoking of stramonium leaves, and possibly the excessive use of opium. It is also seen in the early stages of sclerosis of the brain or spinal cord, and as a symptom of retrobulbar neuritis, which may be associated with various constitutional disorders.

What significance belongs to other defects of the visual field?

If the field of but one eye is defective, the lesion is situated in front of the optic chiasm. Defects involving similar parts of the fields of both eyes—homonymous defects—indicate a lesion behind the optic chiasm. This is true whether the defect involves, approximately, half the visual field (*hemianopsia*) or only a small portion (*sector defect*).

Irregular defects of the field in one or both eyes, or more extensive in one eye than in the other, may arise from pressure on some part of the chiasm.

What does hemianopsia indicate, as to the location of the lesion causing it?

That it is situated back of the optic chiasm. It may affect the optic tracts, as they wind around the cerebral peduncles,

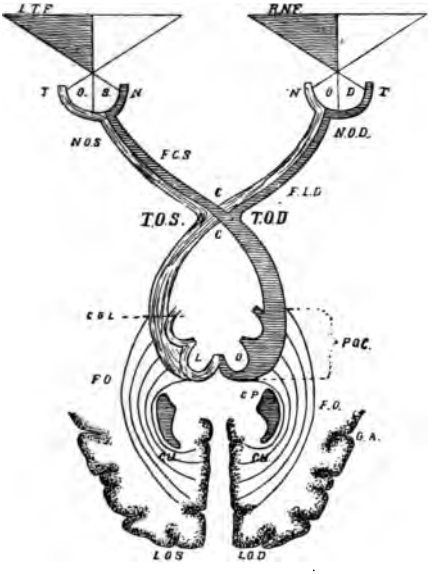

FIG. 80.—Visual paths and centers (Seguin): *R. N. F.*, right nasal field; *L. T. F.*, left nasal field; *O. D.*, right, *O. S.*, left eye; *T.*, temporal, *N.*, nasal retina; *N. O. D.*, right, *N. O. S.*, left optic nerves; *C.*, chiasm; *T. O. D.*, right, *T. O. S.*, left optic tract; *P. O. C.*, primary optic centers; *F. O.*, optic radiations; *Cu.*, visual cortex; *L. O. D.* and *L. O. S.*, occipital lobes.

in close contact with the meninges of the brain, and at first with the sphenoid bone at the base of the skull. It may involve the tract where it passes upward, in close relation with the lenticular nucleus and the internal capsule. After the division of the tract into three parts, one going to the anterior

colliculus of the corpora quadrigemina, one to the pulvinar, and one to the external or lateral geniculate body, only lesions involving the last of these cause hemianopsia. Back of the geniculate body, the damage may occur to the optic radiations of the occipital lobe, or to the cortex lying immediately about the calcarine fissure, on the mesial surface of that lobe.

How do we judge which part of the tract is affected?

By the associated symptoms. If the lesion affects the cortex, no subjective sensations of light are perceived. If the lesion involve the tract or optic radiations, there may be noticed, especially during the first few days, a strong sensation of light throughout the blind portion of the field, or flashes of light or even visual hallucinations. If the lesion is situated near the optic chiasm, there may be palsies of some of the ocular muscles, pointing to involvement of the third, fourth, or sixth cranial nerves.

What significance has the hemianopic reaction of the pupil?

The contraction of the pupil to light depends upon impulses passing from the retina through the optic tract to the anterior colliculus, thence to the nucleus of the third nerve in the medulla, and back to the iris through the nerve-trunk. A lesion that interrupts the optic tract in front of where the fibers are given off to the anterior colliculus causes hemianopsia, and also prevents the reaction of the pupil to light thrown on the blind half of the retina. But if the lesion occur back of this, in the geniculated body, optic radiations, or cortex, hemianopsia is caused, but the reaction of the pupil is not interfered with. This so-called *Wernicke symptom* is of great importance in locating the lesion causing hemianopsia.

DISEASES OF THE NERVOUS SYSTEM.

What may an examination of the eyes reveal in coma, convulsions, or delirium?

Extreme contraction of both pupils indicates narcotic poisoning, usually by alcohol or opium. Extreme dilatation indicates mydriatic poisoning, reflex amaurosis, or the approach

of death. Inequality of the pupils and conjugate deviation of the eyes point to a focal lesion affecting one side of the brain, as from apoplexy or traumatism. Optic neuritis may demonstrate chronic, organic disease of the brain. Albuminuric retinitis will point to uremia, and other forms of retinal disease may reveal syphilis or malaria.

What may an examination of the eyes tell of headache, nausea, or vertigo?

These may be due wholly to eye-strain arising from errors of refraction; to weakness or paralysis of one or more of the ocular muscles, or an underlying, organic cause for them may be revealed by optic neuritis or changes in the retina.

What are the eye-symptoms of diseases of the spinal cord?

Acute *myelitis* may be attended with double optic neuritis. Injuries or *spinal caries*, involving the cervical portion of the cord, may cause contraction of the pupil and slight narrowing of the palpebral fissure through paralysis of the cervical sympathetic; or spastic dilation of the pupil, widening of the fissure, and apparent exophthalmos through irritation of the same nerve. Primary, gray optic atrophy occurs in one out of every four or five cases of *locomotor ataxia*. Sometimes it precedes all other symptoms, even by many years. Sometimes it appears early in the ataxic stage, and then the disorders of locomotion, and sometimes the other symptoms, are likely to diminish or remain stationary for many years. Partial or complete palsies of the ocular muscles often occur early in this disease. They may be transient or permanent. Retrobulbar neuritis with central scotoma also occurs in spinal sclerosis.

How may the eye be affected in multiple neuritis?

The optic nerve may be involved in a retrobulbar neuritis with central scotoma; or paralysis of one or more ocular muscles may occur from involvement of the nerve-trunks supplying them.

What is the connection of the eyes with chorea?

Acute chorea—Sydenham's chorea—may be predisposed to by eye-strain, causing a depressed condition of the general

nervous system. It may be attended by irregularities of the eye muscles, but it does not depend generally or directly upon faults of the muscular balance of the eyes. Reflex *choreic movements* of the face very often arise from eye-strain. *Habit spasms*, or habit choreas, arise from eye-strain and are cured by its relief; but only in a minority of cases.

Does eye-strain cause epilepsy?

In a few cases it gives rise to epileptiform seizures, which cease as soon as it is removed. It may also help to produce a depressed condition of the nervous system, tending to aid in establishing the disease, or to increase the frequency of the seizures when it is established. But it is not a general or essential cause of true epilepsy.

What eye-symptoms attend the epileptic seizure?

The aura may be a visual sensation or hallucination. Contraction of the retinal arteries has been noticed at the beginning of the attack; distention of the retinal veins is common at the close. Lowered acuteness of vision and narrowing of the visual field are often found after the attack, and more rarely preceding it. Violent seizures may cause conjunctival ecchymosis, and cataract sometimes ensues.

What are the eye-symptoms of tetany?

Temporary impairment of distant vision, probably through spasm of the ciliary muscle, and precocious cataract.

What share have the eyes in migraine?

In a large proportion of cases, the disease arises from eye-strain; and whatever its cause, eye-strain will aggravate it. The seizure often begins with certain visual sensations; a blurring of some part of the field, in which there is apt to be a quivering movement like that of heated air; often with flashes of light, *scintillating scotoma*. This may take a form compared to a fortification with re-entering angles. Or it may appear like a jet of water; or some distinct object, as a ball of fire or even a face. It usually comes on suddenly, and gradually fades away in from five to thirty minutes. As it disappears the headache begins. Such visual disturbances are not confined to migraine due to eye-strain.

What are the eye-symptoms of exophthalmic goiter?

The lids are more widely separated than the normal—*Dalrymple's sign.* Their movements of winking are incomplete and occur at prolonged and irregular intervals—*Stellwag's sign.* The upper lid fails to follow the movement of the globe upon looking down. It remains elevated, so that more or less of the sclera shows above the cornea when the eyes are turned downward—*Graefe's sign.* The abnormal separation of the lids causes the eyeball to appear more prominent, even if it be really not pushed forward. But in most cases there is an actual protrusion, which may become so great that the lids cannot cover the cornea. Because of exposure in these cases, the cornea may become inflamed and ulcerated, or it may slough, causing the destruction of the eye. Usually both eyes exhibit these symptoms in different degrees, but they may be confined to one.

What treatment may the eyes require in exophthalmic goiter?

Eye-strain may have an important influence upon the disease by causing or keeping up a condition of depression of the general nervous system. Therefore it should be removed in all cases. Where the condition has become permanent, and the exophthalmos causes unsightly deformity, it may be worth while to remedy this by uniting the lids for a few millimeters from the outer canthus. Attempts have been made to prevent sloughing of the cornea by union of the lids near their center, or throughout the greater part of their length. But such attempts have failed to effect the desired object. The lids break loose, and the condition of the eye is aggravated by the sutures intended to hold them together. When the usefulness of an eye has been destroyed by sloughing of the cornea, suffering will be prevented and the chances of saving the other eye slightly improved by early removal of the sightless stump.

What are the eye-symptoms of akromegaly?

Pressure on the chiasm by the enlarged pituitary body tends to cause defects in the temporal portion of both visual fields. The destruction of the chiasm may be complete,

causing typical, bitemporal hemianopsia. Usually the defects of the fields are irregular and unequal in the two eyes. Parts of the nasal field may be affected by pressure on the optic tracts. The headaches that attend the disease are often ascribed to eye-strain and may be aggravated by it. The skin of the lids and bones of the orbit share in the general hypertrophy. Exophthalmos, optic neuritis, optic atrophy, slowness and incompleteness of the ocular movements and reactions of the pupils, nystagmus, and hypersecretion of tears have been observed.

What are the forms of mind-blindness?

Familiar objects may be accurately described by the patient, and yet quite unrecognized when presented, although vision remains perfect. In another form there remains no recollection of the appearance of most familiar persons or things. Sometimes there is complete inability to recognize written or printed words, although the letters composing them can be correctly named (*word-blindness—alexia*).

In other cases the patient finds it impossible to name the letters, although these are distinctly seen (*letter-blindness*). In still another class, the patient can read correctly, but does it with such a sense of insurmountable difficulty that he can only be induced to continue reading for a few words at a time, and then what is said becomes quite irrelevant and incoherent (*dyslexia*). *Developmental alexia*, inability to remember words or letters, prevents the child from learning to read, even up to adult life, although he may be bright and well advanced in every other way. It demands special training in reading, outside the ordinary school classes.

What ocular conditions attend neurasthenia?

Eye-strain is a very important factor in its production. Pain in the eyes, variable weakness, and lack of balance of the eye muscles are common symptoms. Twitching of the lids is complained of and persistent after-images. The field of vision may be contracted or inclined to contract rapidly while being taken, giving it a spiral boundary. Central vision is sometimes impaired. The optic disk is hyperemic,

its periphery appearing very red in comparison with the central cup, which remains normal in color.

What conditions of the eyes accompany insanity?

None that are characteristic. The impression ascribed to the eyes of the insane lies chiefly in the lids and the muscles of other parts of the face. There may be presented the eye-symptoms of neurasthenia, or those which accompany organic disease of the brain, or such causes of insanity as syphilis or albuminuria.

What are the usual ocular symptoms of hysteria?

The motor symptoms include squint, most frequently convergent and spasmodic; blepharospasm, either clonic or tonic; dilatation or contraction of one pupil, and muscular asthenopia.

The sensory manifestations include contraction of the field of vision, as in neurasthenia; reversal of the boundaries of the color-fields, as the field for red extending beyond the field for blue. Impairment of acuteness of vision, amounting even to complete blindness of one or both eyes.

How is hysterical or feigned blindness of both eyes detected?

Place before one eye a prism of eight centrads, with the base toward the temple, the eyes being turned toward a bright flame in a comparatively dark room. If the flame is seen, the eye before which the prism is placed will involuntarily turn toward the nose to prevent double vision; and on removal of the prism it will turn back to its original position. If the patient is really blind, no such movement of the eye will occur. In acute blindness, if complete, the pupils will be dilated and will not react to light, but in chronic blindness the pupils may be but little larger than normal; and they may still react to light, even though the vision may be so poor as to amount to practical blindness. Sometimes feigned blindness has been demonstrated by giving the patient a general anesthetic and securing evidence of vision during the succeeding period of intoxication. Sometimes the character of the case has been unmasked by suddenly presenting before the patient's eyes some terrifying object.

What is the objective test for hysterical or pretended blindness in one eye?

Place an eight-centrad prism, with its base out, before the alleged blind eye, and if really blind no movement will occur. But if the blindness be hysterical or feigned, the eye will turn toward the nose to avoid double vision, and on removal of the prism will turn out again. During these movements the other eye will remain fixed, or will only quiver slightly from the effort to keep its direction while the eye behind the prism is moved. If then the prism is placed before the other eye the same movements occur, except that these are transposed with the prism. If, however, one eye were really blind, the prism placed before the seeing eye would cause both to move together and to an equal extent; while before the blind eye it would cause no movement. It is possible for an eye affected with hysterical blindness to behave like an eye permanently blind, but this very rarely happens.

What are the diplopia tests for pretended monocular blindness?

Place a prism of about five centrads, with its base up, before the alleged blind eye. The patient will claim that it causes no change in the appearance of objects; now place it in the same way before the seeing eye, and he will generally admit that it causes diplopia. But such double vision proves that both eyes see. If the pupil is large enough, hold the edge or, better, the base of the prism before the seeing eye, so that light shall enter it partly through the prism and partly alongside of it. This should cause diplopia in the seeing eye alone. Denial of this double vision proves falsehood. Now slip the prism wholly in front of the eye, and it will no longer cause double vision with the one eye. If the patient still sees double, the vision of the other eye is proved. A prism, the base of which is continuous with a plate of glass having parallel sides, to be used in this way, constitutes *Baudry's test.*

What is the exclusion test for pretended blindness?

Place before the alleged blind eye its correcting lens, and before the other a spherical lens so strong (10 D.) as to prevent any distinct vision. Ask the patient to read with both

eyes. What he sees is necessarily with the eye alleged to be blind. Thus its acuteness of vision may be measured. (*Harlans' test.*) Instead of the strong spherical lens placed before the seeing eye use two strong cylindrical lenses so turned as to neutralize each other. The patient may be allowed to read through these. Then by turning one of them ninety degrees in the trial frame, vision with this eye will be prevented, and what he reads will give the acuteness of vision in the alleged blind eye (*author's test*).

DISEASES OF THE CIRCULATORY SYSTEM AND KIDNEYS.

What are the eye-symptoms of simple anemia?

Acute anemia from hemorrhage may cause sudden blindness with swelling and edema of the disk, sometimes followed by optic atrophy.

In chronic anemia the sclera is pearly white; the inner surface of the lids pale; the optic disk pale and uniform in color; the retinal arteries normal or slightly contracted and pale; and the larger retinal veins much broader than normal, pale, and with a broad, light streak from flattening of the vessel by partial collapse.

What eye-symptoms attend leukemia and pernicious anemia?

The changes in the retinal veins seen in simple anemia are greatly exaggerated, and a form of neuroretinitis arises characterized by great edema and swelling, and numerous flame-shaped hemorrhages into the retina. It occurs usually late in the course of the disease. Lymphoid tumors of the lid and orbit, or the green tumors called chloroma, may occur.

What eye-symptoms appear in diseases of the heart?

General edema attending heart-disease, although not especially likely to involve the eyelids, may first be noticed in this situation, particularly on rising in the morning. Pulsations of the retinal arteries are seen in aortic regurgitation, or when the blood-pressure is lowered from other causes, as in syncope. It may also be seen with sudden excitement of the

heart's action. Embolism of the central retinal artery may be due to endocarditis; and distended, tortuous, retinal veins may arise from distention of the right heart and venous system.

What eye-symptoms may be found with aneurism?

Affecting the aorta, innominate, or common carotid artery, it may, through irritation of the cervical sympathetic, cause dilatation of the pupil, widening of the palpebral fissure, and exophthalmos. It may also cause embolism of the retinal artery. Aneurism of the internal carotid within the skull may cause palsies of the ocular muscles, or may break into the cavernous sinus and cause pulsating exophthalmos.

How is sclerosis of the vessels revealed in the eyes?

Retinal hemorrhages may occur at an early stage. Later, the walls of the vessels, as seen with the ophthalmoscope, may be notably thickened and opaque. Both arteries and veins become somewhat irregular in caliber, and the finer branches of the veins particularly dilated and tortuous. These changes are attended with signs of retinal degeneration, swelling, opacity, and white specks, or larger gray areas, with deterioration of vision.

What are the ocular symptoms of Bright's disease?

In chronic interstitial nephritis, the above changes, indicative of angiosclerosis, with marked evidence of degeneration, are very likely to appear at the period when the blood-pressure is no longer sufficient to continue nutrition at the normal standard. The usual form of albuminuric retinitis has been described (see page 169).

Retinal hemorrhage is a very constant attendant; retinal edema is frequent and detachment may occur. Palsies of the eye muscles may also occur. Amaurosis due to uremia is sudden and usually complete. But the pupils continue to react to light. The dropsy of kidney disease is often first noticed in the eyelids, but it may exist without appearing there at all.

What is the prognosis of albuminuric retinitis?

It is an evidence that the patient is breaking down and the

disease approaching a fatal termination. But few patients live more than two years after well-marked lesions are found in the retina. Exceptions to this prognosis must be made of cases arising in connection with acute nephritis and with pregnancy. And a very few cases of chronic nephritis survive the appearance of retinal lesions for many years. The sight is rarely entirely lost. But in a few cases hemorrhagic glaucoma supervenes, destroying it.

What are the eye-symptoms of diabetes?

Cataract, which is apt to come on rapidly, the clouding of the lens being diffuse; but the case otherwise resembling cataract from other causes in a patient of the same age.

Diabetic retinitis is characterized by ivory white dots, most numerous in the center of the fundus, but not arranged in any regular figure. With these may occur small hemorrhages, white plaques, or spots of altered pigmentation. *Retinal hemorrhages* may be numerous and extensive. *Retrobulbar neuritis*, with central scotoma, may occur and may end in optic atrophy. *Iritis* may be due to diabetes. Sudden great *changes in refraction* sometimes attend it; and it may cause *palsies of the ocular muscles.*

CHRONIC DISEASES.

What are the eye-lesions of gout?

A chronic inflammation of the retina, optic nerve, and choroid, closely resembling that of angiosclerosis; *iritis* running a very insiduous course, and showing a strong tendency to relapse; a recurring *dry catarrh of the conjunctiva*, marked with intense burning and severe hyperemia; *scleritis;* sclerotising keratitis, and superficial painful ulcer, near the corneal margin in old people, are regarded as of gouty origin.

What are the eye-lesions in rheumatism?

Rheumatic *iritis* is marked by severe pain and hyperemia and the early formation of synechia, which are apt to be narrow, and which stretch or tear asunder under a mydriatic. Often but one eye is affected, but repeated attacks are liable to occur. They may accompany outbreaks of acute rheuma-

tism, but more frequently the iritis appears in the subacute or chronic forms of the disease, or not associated with the acute attacks.

Rheumatism is accredited with causing 20 or 30 per cent. of the acute *palsies of the ocular muscles.* It also causes scleritis and episcleritis. Rheumatic endocarditis may give rise to *embolism* of the retinal arteries.

What are the eye-symptoms of purpura?

Hemorrhage may occur into the retina, choroid, conjunctiva, or lids. In the depths of the orbit it may be so extensive as to cause exophthalmos. Probably the same lesions sometimes occur in *scurvy.*

What eye-diseases are regarded as strumous?

Chronic inflammation of the lid margins, phlyctenular disease of the conjunctiva and cornea, and some cases of interstitial keratitis. These diseases may depend on tubercular infection of some portions of the lymphatic system, not upon direct tubercular infection of the eye.

How does tuberculosis involve the eye?

It may appear in the iris as scattered, minute deposits, or as a single large mass, attended with chronic iritis. It may take the form of lupus of the lids, or may involve the conjunctiva, causing a chronic inflammation, with firm, nodular swelling and ulceration. It appears in the form of large masses involving the choroid and retina, or small choroidal deposits at a late stage in general tuberculosis. But tubercular disease of the eye is rare. Tubercular meningitis or brain-tumor of tubercular character causes the usual symptoms of organic brain-disease.

How does chancre occur about the eye?

Infection is usually carried by the fingers or tongue, but often no history can be obtained. Upon the lids it appears as a small ulcer upon a greatly swollen, indurated base, lasting several weeks, and comparatively painless. In the conjunctiva it may be situated near the inner canthus, in the lower cul-de-sac, or very rarely in the upper. It here presents a hard base with moderate swelling. Whether situated

on the lids or conjunctiva, the early involvement of the preauricular glands is an important symptom. It is followed by involvement of the lymphatics throughout the body.

What are the eye-lesions of secondary syphilis?

More than half of the cases of iritis are due to syphilis. But in only about 3 per cent. of the cases of syphilis does the iritis occur. The cases in which it does occur are especially liable to grave tertiary manifestations. Among the more frequent syphilitic lesions are cyclitis, choroiditis, chorioretinitis with dust-like opacity of the vitreous, optic neuritis, and falling of the eyebrows and lashes.

What are the ocular lesions of tertiary syphilis?

Gumma may occur in any part of the eye or its appendages. Chorioretinitis, retinitis pigmentosa, optic neuritis, and optic atrophy may all be due to syphilis. More than half the palsies of the ocular muscles are caused by it. Chronic inflammation of the tarsal cartilages sometimes occurs; and there is a form of ulceration of the lids or conjunctiva, with much swelling, that may be differentiated from malignant disease only by its improvement under specific treatment. Glaucoma may follow syphilitic iritis.

How is the eye affected by inherited syphilis?

Interstitial keratitis is usually due to this cause, although it may occur late in acquired syphilis or in the strumous and non-syphilitic. It is often accompanied by inflammation of the iris, ciliary body, or choroid. Most cases of retinitis pigmentosa and of congenital opacities in the cornea are due to inherited syphilis. Some of the most serious inflammations of the lacrimal passages, arising in young persons, are also due to this cause.

What are the ocular manifestations of gonorrhea?

Purulent conjunctivitis (see page 96) in the newborn and in adults is commonly due to conjunctival infection by the gonococcus. The cornea is liable to be involved in purulent conjunctivitis; and staphyloma or leucoma may remain as a permanent condition. A truely metastatic inflammation may occur, probably due to toxins, without the coccus appearing

in the conjunctiva. Such an inflammation is brief and not attended with purulent discharge. Iritis may appear early, running an acute course with much exudation, but yielding to treatment and ending in good recovery. Or iritis may appear later, running a very chronic course and relapsing with any relapse of the urethral discharge.

How does leprosy affect the eye?

The lids may present anesthetic patches or nodules, and the latter may cause such deformity as to lead to disease of the cornea from exposure. The eyebrows and lashes may be destroyed, nodules are especially apt to appear at the corneal margin, and the deeper tissues of the eye may be involved. Sight may be lost through anesthesia of the cornea and neuro-paralytic ophthalmia.

How is the eye affected in malaria?

The peculiar form of keratitis due to malaria is described on page 109. Retinal hemorrhages and hemorrhages into the vitreous are not rare in the malarial disease of certain regions. Retinochoroiditis or optic neuritis may occur; or sudden blindness, which may be permanent, with optic atrophy. Malarial neuralgia is frequently felt in the brow, and may be mistaken for headache due to eye-strain, and *vice versâ*.

ACUTE INFECTIOUS DISEASES.

What significance have ocular hyperemia and photophobia in these diseases?

They are liable to occur in the early febrile stage of any acute infectious disease. The hyperemia is a part of the general febrile movement, while the photophobia indicates irritation of the cerebral meninges.

What eye-symptoms attend measles?

Marked increase of lacrimation, with some hyperemia of the conjunctiva, is apt to appear before any other symptom of the disease, and to develop into a well-marked catarrhal conjunctivitis before the eruption is manifest. Later, even after recovery is otherwise complete, there often remains a

chronic conjunctivitis, either catarrhal or phlyctenular. Sometimes there is a strong tendency to corneal ulceration, ulcers occurring from exposure to very slight injury or irritation, and showing little disposition to heal. In other cases low degrees of ametropia cause excessive annoyance or disability, or there may be persistent asthenopia without any error of refraction. Muscular palsies, optic neuritis, and optic atrophy may be caused by meningitis.

What are the eye-lesions of scarlet fever?

Diseases of the cornea, of the lacrimal gland, or lacrimal passages are sometimes set up. There may also be orbital cellulitis or the eye-lesions of meningitis. Involvement of the kidneys may give rise to uremic amaurosis or, later, to albuminuric retinitis.

How is the eye affected by diphtheria?

Diphtheritic conjunctivitis (see page 99) occurs without evident involvement of other mucous membranes. Paralysis of accommodation is the most common form of diphtheritic paralysis. The blurring of near vision which it causes is usually first noticed during convalescence. It continues for several weeks, but ends in recovery. Paralysis of one or more of the extra-ocular muscles, causing double vision and squint, may appear still later. It often shows a strong tendency to recovery, but if neglected, the squint may become permanent. Without paralysis of the extra-ocular muscles convergent squint may be caused by excessive effort with the weakened accommodation.

What ocular lesions follow influenza?

Weakness of accommodation and of the extra-ocular muscles, with severe asthenopia, may continue for weeks, or even many months, but end in ultimate recovery. Retrobulbar neuritis and optic atrophy have been reported. Lens opacity may grow rapidly worse during the attack and immediately afterward. Vitreous opacities may appear. Inflammation of the cellular tissue of the orbit going on to suppuration has been reported; and subsequent glaucoma has been ascribed to influenza.

How are the eyes affected in small-pox?

The eruption may involve the conjunctiva and lids, and thus, by cicatricial changes, may cause deformity of the lid margins or displacement of the lashes. But the primary eruption rarely or never affects the cornea. Later, however, in the second week of the disease or subsequently, corneal ulceration often appears, and usually leaves a permanent scar, or it often goes on to perforation, causing blindness.

What is vaccinia of the lids and conjunctiva?

Conjunctival hyperemia may attend the ordinary fever after vaccination. Sometimes vaccination has been purposely done on the lids to destroy a nevus. In other cases the eye has become accidentally infected by means of the fingers. The lids become greatly swollen and indurated, and there is involvement of the related lymphatic glands. At the height of the disease the conjunctiva may present a croupous deposit, but the cornea escapes without damage; and recovery rapidly occurs when the general fever has run its course.

How may the eye be affected by chicken-pox?

A subacute or chronic conjunctivitis is sometimes left, with liability to corneal ulcer, very much as after measles.

How does whooping-cough affect the eye?

The violent straining of the coughing spell causes hemorrhage. When this is located under the conjunctiva, it may be so profuse or so renewed by successive spells of coughing as to require several weeks for its removal. It may occur in the depth of the orbit, causing exophthalmos, or optic atrophy and permanent blindness by pressure on the optic nerve.

How may the eyes be affected by mumps?

The swelling about the parotid gland may extend to the lids and, in rare cases, the lacrimal glands become similarly affected. Exophthalmos, and optic neuritis followed by permanent impairment of the vision, and optic atrophy have sometimes seemed to be due to this disease.

How are the eyes involved in cerebrospinal meningitis?

Usually there is conjunctivitis. Thrombosis of the retinal

veins and retinal hemorrhages, plastic inflammation of the iris and choroid, and purulent inflammation of the choroid and retina, causing pseudoglioma, occur. Optic neuritis and optic atrophy may appear. Inequalities, dilatation, and contraction of the pupils are common; and palsies of the extra-ocular muscles occur. Many of the cases presenting the grave ocular lesions do not survive the attack, but among those that do, permanent impairment of vision or complete blindness is common.

How does erysipelas involve the eyes?

The lids become greatly swollen, and involvement of the cellular tissue of the orbit is likely to cause abscess. Thrombosis of the retinal vessels, optic neuritis, and inflammation of the lacrimal gland and lacrimal sac are liable to occur. It may give rise to glaucoma or to optic atrophy.

How is the eye affected in septicemia?

An inflammation of the retina or choroid, or both, occurs, apparently caused by minute emboli; these may give rise to small foci of inflammation, which appear as white spots, with hemorrhages; or they may set up a more general purulent inflammation, ending in pseudoglioma. In other cases embolism of the retinal vessels and retinal hemorrhages occur.

What eye-lesions are due to typhoid fever?

In the typhoid state the cornea is apt, through exposure, to become dry, hazy and inflamed, or ulcerated. Inflammation of the choroid with more or less opacity of the vitreous may occur. In rare cases there is optic neuritis. During convalescence there is likely to be weakness of accommodation and asthenopia.

How is the eye endangered by relapsing fever?

There is liable to ensue, after some weeks, cyclitis, or more general inflammation of the uveal tract, with vitreous opacity; and this may end in panophthalmitis or in shrinking of the eyeball.

What are the eye-symptoms of cholera?

The eye becomes sunken from the general loss of fluid and

the retinal veins are contracted, while the retinal arteries become the color of retinal veins. The cornea generally suffers from exposure, and if the patient survives severe keratitis occurs, but usually terminates in recovery.

What are the eye-symptoms of yellow fever?

Conjunctival hyperemia and excessive lacrimation are usually quite marked in the beginning. Later, the general yellow discoloration of the tissue involves the eye, and hemorrhages, both subconjunctival and retinal, may occur.

DISEASES OF SPECIAL ORGANS.

What ocular conditions arise from disease of the nose?

Acute coryza is often attended with frontal headache like that from eye-strain. Chronic or frequently recurring catarrhal rhinitis is attended with relapsing, phlyctenular disease, and must be cured before the eyes can be restored to normal.

Diseases of the lacrimal duct and sac are often caused by extension from the nose. Lacrimal obstruction may be due to closure of the lower end of the duct by chronic hypertrophic rhinitis or cicatricial contraction, following acute inflammation or chronic atrophic rhinitis. Some of the worst cases of lacrimal disease arise from caries of the bones of the nose.

What eye-lesions are associated with disease of the frontal, ethmoid, or sphenoid sinuses?

Malignant disease starting in them generally extends into the orbit. Ivory exostosis of the orbit starts in the frontal or ethmoidal sinuses. Optic atrophy is sometimes associated, with the dropping of watery fluid from the nostril and polypoid growths originating in the ethmoid. Strabismus may be associated with a similar condition. Temporary amblyopia, and even optic neuritis, have been caused by active local treatment of the upper part of the nose, particularly with the galvanocautery. Closure of the ethmoidal cells gives rise to tenderness in the orbit, and headache like that of eye-strain. Mucocele or empyema of these sinuses is likely to cause tumor and, later, abscess of the orbit through destruction of the bony wall. Vitreous opacity and weakness of accom- may be due to sinus disease.

What may result from disease of the maxillary antrum?

It very frequently makes its way into the orbit. Sometimes directly through the orbital floor, and in other cases through the ethmoidal sinus.

What eye-lesions are due to disease of the teeth?

Abscess, starting about the root of an upper tooth, may extend, usually by way of the antrum, into the orbit. Periostitis from a similar source may reach the orbit, and has caused optic neuritis and optic atrophy. Paresis of accommodation is the most common symptom of dental disease. Spasm of the accommodation may also occur. Muscular asthenopia and squint have been ascribed to this cause. Dental irritation may give rise to severe blepharospasm. Inflammations of the conjunctiva, cornea, and iris have also been traced to dental caries.

What is the influence of the stomach on eye-disease?

Gastric hemorrhage is more liable to cause permanent blindness than hemorrhage from any other organ. The headaches from eye-strain are very generally aggravated by derangements of the stomach or errors of diet. Many of these headaches must be regarded as of double origin, and in some cases removal of either factor gives relief. In other cases both must be attended to in order to effect a cure. Because relief has been afforded by treatment in the one direction at one time, it must not be forgotten that treatment in the other direction may be the essential at a subsequent time. A form of severe amblyopia is sometimes encountered that appears to arise from auto-intoxication due to chronic gastro-intestinal disorder; and it is only to be relieved by prolonged, careful treatment of the gastro-intestinal tract.

What eye-conditions attend disease of the liver?

Yellow vision is sometimes noticed in jaundice. It is uncertain whether this is due to coloring matter in the dioptric media or to some influence on the retina. Retinal hemorrhage is quite common in connection with those diseases that cause jaundice. Chronic choroidal disease and a low grade of neuroretinitis have been observed in connection with chronic disease of the liver.

What eye-diseases are associated with diseases of the sexual organs?

Retrobulbar neuritis occurs chiefly during the period of active sexual life, and twice as frequently in women as in men. Optic atrophy and spontaneous retinal hemorrhage, in young men, seem to be caused by sexual excesses. Albuminuric retinitis arising during pregnancy may threaten complete blindness. It then becomes an important indication for the induction of abortion or premature labor. (See page 169.) Optic atrophy may occur from prolonged lactation, causing anemia. Menstruation influences strongly chronic inflammatory diseases, especially of the uveal tract. Arrest of menstruation may cause intra-ocular or subconjunctival hemorrhage.

What are the ocular signs of death?

At the moment of death the pupil is often noticed to dilate widely. The blood columns in the retinal vessels, as seen with the ophthalmoscope, become at first finely granular, then they may break up into beadlike masses, and the movement grows slower and slower, until within one or two minutes it ceases altogether. Postmortem changes begin early in the eye and are quite characteristic. The retina and the dioptric media become hazy. The sclera becomes discolored and the eye retracted by rigor mortis.

TOXIC AMBLYOPIAS.

What are the symptoms of tobacco-amblyopia.

Impairment of vision, coming on rapidly, sometimes within two or three days, and variable in amount. The patient complains of a cloud or blur before his sight; and on testing the field of vision it is found that the impairment is limited to the neighborhood of the fixation-point. On careful testing it will always be found that at the center of the field color-perception is interfered with. In a small area, sometimes not more than two or three degrees across, colors, especially red and green, are seen very badly, or color-blindness is complete. The clouding of vision and a central color-scotoma in a person using tobacco may be considered to establish the

diagnosis. The ophthalmoscope reveals no constant, characteristic change. Often the disk appears a dirty red and slightly blurred in the early stage; and later, in bad cases, there may be atrophy, causing the outer quadrant of the disk to appear pale or greenish.

What are the causes of tobacco-amblyopia?

Exposure to the toxic influence of tobacco. This may be through its consumption in any form, most frequently by smoking; or even by working in it. It usually occurs after forty years of age, although cases have been reported in which it appeared before the age of twenty. Occurring in early life, it is commonly due to great excess in the use of tobacco combined with the excessive use of alcohol. After fifty it may arise, although the amount of tobacco consumed is much less than had been habitually used in early life. Race and the variety of tobacco employed seem to exert an important influence. The occurrence of the disease generally accompanies some impairment of general health, particularly affecting digestion and general nutrition.

What is the treatment for tobacco-amblyopia?

Complete avoidance of tobacco, the use of general tonics, and especial measures to improve digestion; the use of potassium iodid in moderate doses for some weeks in the beginning, and later, strychnin in ascending doses, to the point of distinct physiologic action. With strychnin, begin with $\frac{1}{24}$ of a grain at a dose, three times a day. Then make the dose $\frac{1}{20}$, $\frac{1}{16}$, and $\frac{1}{12}$ of a grain successively, and so on until stiffness of the neck or jaws, or unpleasant jerking, a short time after taking the medicine, gives warning that the maximum dose has been reached. Many patients will take as much as $\frac{1}{6}$ of a grain at a dose, three times a day, if this amount is reached gradually. The drug may also be administered hypodermically in the same ascending doses, given once each day or two. As soon as marked improvement in vision occurs, we may cease increasing the dose, continuing the amount then given until vision has been fully restored or further improvement ceases. If no decided improvement occurs the dose must be increased

to the maximum, and continued for many weeks or months just below that which causes symptoms of poisoning.

What is the prognosis of tobacco-amblyopia?

If treatment is begun early and the patient abstains completely from the use of tobacco, it is very good. Sometimes good recovery occurs although improvement has not been apparent for several months. If neglected it does not cause absolute blindness. But central vision becomes so impaired that the patient is unable to follow any ordinary occupation.

What is alcohol-amblyopia?

It closely resembles tobacco-amblyopia, but is more likely to appear at an early age, and to include narrowing of the periphery of the visual field; to be followed by general atrophy of the optic nerve, and to be less amenable to treatment. In a majority of cases the disease is caused by the abuse of both drugs, and has been termed "amblyopia ex abusu." The treatment is that given for tobacco-amblyopia. Complete abstinence is usually essential to a cure.

What is iodoform-amblyopia?

Clouding of the field of vision; central scotoma, and central color-blindness, with or without narrowing of the field. It occurs from the use of iodoform dressings upon large raw surfaces produced by burns or wounds; or from the prolonged internal use of the drug in large doses. It is attended with other symptoms of iodoform-poisoning—stupor, delirium, headache, diarrhea, fever, and rapid soft pulse. The treatment is the same as for tobacco-amblyopia, including immediate cessation of the use of the drug.

What is bisulphid-of-carbon amblyopia?

A condition similar to tobacco-amblyopia, arising in workmen who inhale the fumes of this substance, used in vulcanizing rubber. The general symptoms of poisoning which accompany it are: at first, irritability, excitement, and vertigo; later, dejection, cutaneous anesthesia, muscular weakness, and loss of memory. The important point in combating it is cessation of exposure to the cause.

What is the essential lesion of the foregoing amblyopias?

It appears to be a degeneration of the nerve-fibers which supply the center of the retina, the so-called papillomacular bundle, with degeneration of the nerve-cells in the retina, with which they are related or from which they arise, attended with increase of the connective-tissue elements of the nerve. It is often classed as a retrobulbar neuritis.

What is nitrobenzol-amblyopia?

An impairment of vision affecting, to various extents, the whole field, which arises in workers exposed to the dust and fumes of nitrobenzol, and closely allied substances, employed for making certain explosives and perfumes. The pupil is dilated and the ophthalmoscope shows the eye-ground darker than normal, especially the vessels, the retinal veins being large and tortuous. The amblyopia is accompanied by headache, muscular weakness, cyanosis, and mental disturbance. Recovery usually occurs if the patient can avoid further exposure.

What is the blindness caused by wood alcohol?

The patient, after prolonged unconsciousness from a single excessive indulgence, may awaken to find himself blind. More frequently intoxication by this substance is succeeded by vomiting, intense gastro-intestinal pain, and partial collapse. Then in a few hours sight is lost. The same train of symptoms has arisen from the prolonged inhaling of the vapor in a confined space. The blindness is at first nearly or quite complete. After a few days vision returns and improves, until the patient may think he has almost recovered. But at this time there usually begins contraction of the field of vision and optic atrophy, which progresses to almost complete and permanent blindness. Cheap essences of Jamaica ginger, lemon, etc., are frequently the forms in which the poison is taken.

What can be done for wood-alcohol poisoning?

Get the poison out of the stomach and intestines as soon as possible. Apply external heat. Give in moderate quantities such stimulants as ethyl alcohol, coffee, and strychnia. Use pilocarpine sweats and potassium iodid. It is only in the early stage that much can be done to prevent blindness.

What are the symptoms of quinin-amblyopia?

After a large dose (15 grains to 1 ounce in the twenty-four hours) the usual symptoms of quinin-poisoning—vertigo, ringing in the ears, and deafness—occur, and usually pass off entirely before any impairment of vision is noticed. Then dimness of sight begins, and in a few hours the patient becomes absolutely blind. Subsequently some vision returns, but in a greatly narrowed field. In most cases central vision and color-perception again become useful or even normal. But in even the lighter cases the field of vision for form, and particularly for colors, remains permanently contracted. The ophthalmoscope shows the optic disk to be completely blanched and the retinal vessels greatly contracted. These symptoms remain to a considerable extent even when good central vision has been recovered. Other alkaloids of cinchona may cause this form of amaurosis.

What are the pathology and treatment of quinin-amaurosis?

A degeneration begins in the ganglion-cells of the retina and extends to the related fibers of the optic nerve. It appears to be connected with the shutting off of the retinal blood-supply. This seems to indicate the use of amyl nitrite and other nitrites in the beginning of the disease. Hydrobromic acid, the bromids, and potassium iodid have also been recommended. Later, strychnin and general tonics may be tried. After one attack of quinin-amaurosis, that drug must be used only in quite small doses, if at all.

What is salicylic-acid amblyopia?

A condition like that of quinin-amblyopia, produced by excessive doses of salicylic acid or the salicylates. Acetanalid may also cause a similar but less permanent disturbance of vision.

How is vision affected by lead-poisoning?

There may be a transient loss of sight as in uremia. Amblyopia, like that produced by tobacco or alcohol, is met with. Optic neuritis and retinitis may occur, either as direct results or secondary to renal or cerebral disease. Retrobulbar neuritis and optic atrophy, either primary or secondary to iritis, are also reported.

What usual disturbances are caused by other mineral poisons?

Arsenic may cause retrobulbar neuritis and optic atrophy. Optic neuritis has been ascribed to the use of mercury. Phosphorus-poisoning may be attended with fatty degeneration of the retina and retinal hemorrhages. The prolonged internal use of silver nitrate has been credited with causing amblyopia and optic atrophy. Exposure to the vapor of osmic acid has caused amblyopia.

Do tea, coffee, and chocolate cause amblyopia?

Optic atrophy and amblyopia have been ascribed to excessive drinking of coffee. Central color-scotoma has been found among tea-tasters and persons consuming large quantities of strong tea. A few instances are on record of an idiosyncracy to chocolate shown by amblyopia whenever it was taken. This latter is probably connected with digestive disturbances.

What other drugs may cause amblyopia?

Workers with *vanilla* suffer from a condition resembling subacute glaucoma. *Ergotism* is said to cause cataract. *Naphthalin* internally may cause cataract. *Carbonic-oxid poisoning* may cause blindness. And the vapors remaining after the explosion of *dynamite* have caused temporary amaurosis and even optic atrophy. *Cannabis indica* and the *mescal button* cause visual hallucinations. *Filix mas* causes visual disturbance. The effect of mydriatics and myotics is well known. *Gelsemium* causes paresis of the ocular muscles and diplopia. *Sulphonal* has caused ptosis. Poisoning by *ptomains* and *serpent venom* have also caused impairment of vision. Yellow vision has arisen from the last, and it is also a characteristic symptom of *santonin-poisoning.*

TESTS AND REQUIREMENTS OF VISION FOR SCHOOLS, RAILROADS, AND PUBLIC SERVICES.

What tests of vision should be carried out by principals or teachers of schools?

The ordinary card of test-letters may be employed in the usual way. It is better to use a single line of letters visible to the normal eye at twenty feet. The test is placed in a good light, and each two feet marked off on the floor, from the card to twenty feet. The child is placed at twenty feet from the card, and one eye covered, without making pressure upon it. If the letters are all read at this distance, the eye has normal vision. If they are not read at twenty feet, the child should approach until all are distinctly read, and the distance at which this is done should be noticed. Such a test will not reveal the presence of hyperopia or low astigmatism, which might cause very serious eye-strain from school work. But these conditions cannot be certainly determined by anything except a careful examination by an expert.

What constitutes a proper expert examination of the eyes of school children?

Distant vision and color-perception should be tested. The near point of distinct vision carefully determined and the muscle balance ascertained. The appearances of the eyelids, conjunctiva, cornea, and iris should be noted. The dioptric media and ocular fundus should be examined with the ophthalmoscope. The presence or amount of astigmatism should be ascertained by skiascopy. In addition to this, the conditions under which the child is expected to do school work must be carefully investigated, and the bearing of the general

health on the capacity of the eyes for near work should be duly considered.

What are the visual requirements for the United States Army?

For enlistment in the ranks, the recruit is required to count, at a distance of twenty feet, black dots $\frac{4}{10}$ of an inch in diameter, on a white ground. This corresponds to a bull's eye three feet in diameter at a distance of six hundred yards, or to vision of about $\frac{20}{60}$ on the ordinary Snellen scale. Blindness of one eye, marked strabismus, evidence of inflammation of the eyes or lids, or any serious disease of the eye is cause for rejection. For admission and graduation at West Point, vision must be equal to at least $\frac{15}{20}$ in either eye without glasses. Full normal vision in both eyes must be obtained with correcting lenses.

What is required of officers in the navy?

They must show normal color-perception as tested by the Holmgren wools, and vision of not less than $\frac{15}{20}$ in each eye without lenses. These are the requirements both for admission to the naval academy and for graduation therefrom.

What standards of vision may properly be required for railway service?

For engineers and firemen, those entering the service should be required to show acuteness of vision equal to $\frac{20}{20}$ in each eye. This should be without glasses, for young men who are entering the service. Older experienced men should be permitted and encouraged to wear glasses if these will improve their visual acuteness. Vision that will fully serve all practical purposes, as vision of $\frac{20}{80}$, or $\frac{20}{20}$ in one eye and $\frac{20}{40}$ in the other, may be accepted. Absolutely perfect color-perception should be required in all cases. For colored signals must be instantly recognized under the most unfavorable conditions, as through smoke, fog, or snow, and at dusk, or in the daytime with various backgrounds.

The same requirements should apply to men in charge of signal towers, switches, and draw-bridges. For other positions, vision of $\frac{20}{30}$ in one eye, with or without glasses, and good color-perception may be accepted as sufficient.

What tests will insure the requisite acuteness of vision?

The usual one with Snellen test-type (see page 243), but so arranged and conducted as to prevent the possibility of error or deception. To attain this, the eye which is not being tested must be entirely covered without subjecting it to pressure; and there must be some plan for changing the test-type

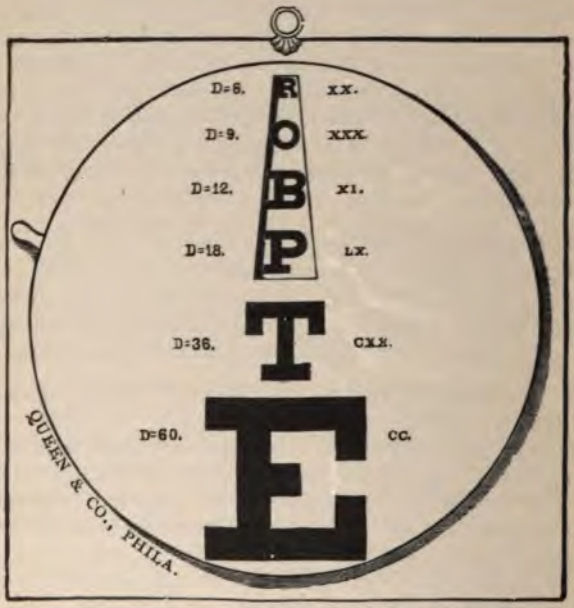

FIG. 81.—Thomson's revolving disk of test-types.

used that will render it impossible for the person tested to repeat the letters from memory. A most effective plan is that of Dr. William Thomson, who uses a circular card of test-letters arranged in columns converging toward the center. This is covered by another card (see Fig. 81), which allows only one row of test-letters to be seen at a time, and gives no indication as to which line of letters is being shown.

What tests are necessary for the exclusion of color-blindness?

The test with the Holmgren wools, which most quickly and certainly reveals the presence of congenital color-blindness; and some test with comparatively small areas of color, usually by some form of lantern, to detect central color-scotoma.

How is the wool-test conducted?

A test-skein of light green is given to the applicant, to be matched by selecting from a mass of mixed wools the skeins most like it in color. A person with normal color-perception quickly selects the greens of the same hue, although most of the skeins would be either lighter or darker shades. The color-blind man, on the other hand, will select, along with some greens, skeins of gray and yellow, or light brown, or at least he will pick up some of these which contain no green, and evidently hesitate before rejecting them. This hesitation indicates imperfect color-perception.

If perfect color-perception has been shown in connection with the green test-skein, the wool-test need proceed no further. But if color-perception is imperfect, a test-skein of rose-pink is given, to be matched in a similar manner. With this the color-blind will place either blue and purple skeins, indicating *red-blindness*, or gray and green, indicating *green-blindness*. A third test-skein of bright red may be employed as a confirmatory test. With it the red-blind will place dark brown, green, or gray, while the green-blind will match it with light green or brown.

What proportion of persons are shown to be color-blind by this test?

About one in twenty or twenty-five men, and one in one thousand of women. These are the usual proportions of cases of congenital color-blindness in the two sexes.

How is central color-scotoma detected?

A hole, three millimeters in diameter, may be made in the center of a sheet of paper. This is to be held one meter fror

the person to be tested, who is to fix his gaze upon the opening. Several skeins of different colors, among which should be green, red, blue, and yellow, are held behind the paper, and one after another presented at the opening. Failure to recognize the color shown, in a good light, indicates color-blindness affecting the fixation-point of the retina; since such an area of color should be readily recognizable beyond six meters or twenty feet. In place of this test, one of the lanterns, to be presently described, may be used at the appropriate distance.

What modifications are required when the tests are to be carried out by lay examiners?

The essential thing is that each color skein shall be designated by a number securely attached to it; and that a blank shall be used, upon which the examiner can mark the numbers of the skeins selected to match each test. The person examined should be required to select as many skeins as there are match-skeins exposed. And the confusion skeins should be sufficiently numerous and carefully selected to reveal even slight defects.

What special apparatus may be used for the purpose?

Thomson's color-stick has forty skeins, twenty match-skeins, and twenty confusion colors, each appropriately numbered, attached to a double stick in such a way that their order can be easily varied, and by closure of the two halves of the stick together the numbers can be entirely concealed. Twenty of the skeins are match and confusion colors for the green test, to reveal color-blindness. Ten are especially selected for the rose-pink test, and ten of match and confusion colors for the red test.

In his new wool-test Thomson employs only the green and rose test-skeins, with ten match and ten confusion skeins for each of the tests shown. The numbers attached to the skeins are concealed in a box, which allows the wools to be thrown into a more confused mass than when arranged on the stick. The box is divided into two compartments, one for the green test, the other for the rose test.

What is the exact method of using this test?

Examine each eye separately, covering the other eye so as to exclude it from vision. Spread a white cloth on a table in a good light. Place on it at random all the skeins from the green part of the box. Take the large light green skein, marked "A," lay it in a good light, and direct the man to select ten skeins from the heap to match it. Tell him these are not to be exactly like it, but of the same general color, only a little lighter or darker in shade.

Record the numbers of the ten skeins selected, and put these skeins back in the green part of the box. Take the skeins from the other part of the box; and ask him to match the large rose-colored test-skein, marked "B," as before. Record his selections.

If the man selects blues with the test-skein "B," he is red-blind; if he selects grays or greens, he is green-blind. Ask him the names of any of the skeins and register his answers. Record whether his selection was prompt or hesitating.

What forms of lantern are especially adapted to testing color-perception?

Dr. C. H. Williams' lantern is furnished with a disk containing four different shades of red, three of green, two of yellow, and one of blue. By turning the disk either color can be placed before the light. A second disk contains apertures of various sizes, from two millimeters up to five millimeters, either of which can be brought before the colored glass in front of the light. The smallest opening corresponds to an ordinary switch-light seen at a distance of fifteen hundred feet. Each colored glass and each opening are numbered, so that a complete record of the correct answers and mistakes made may be kept.

The lamp devised by Dr. Thomson consists essentially of a metal chimney with two attached disks, that can be slipped upon an ordinary lamp. One disk contains the colored glasses corresponding to the usual railway signals. And the other has openings of 1, 2, 5, and 10 millimeters in diameter; ground glass, London smoke of two shades, light pink, light green, and cobalt glasses. The different colors on the

disk are designated by numbers, and the various apertures and glasses on the other disk are indicated by letters.

How is the colored lantern to be used?

The person to be examined is placed at the appropriate distance (twenty feet for Williams', sixteen feet for Thom-

FIG. 82.—Thomson's lamp for testing color-perception.

son's), and asked to name the colors when seen through the 1 millimeter aperture. If he is unable to name them correctly, the 2 millimeter aperture is given, and if he fails with this, the larger apertures in succession. If still unable to recognize the colors, he is allowed to approach the lantern. Then the

size of the aperture required, and the distance at which the colors are all recognized, indicates the impairment of his color-perception. Both correct answers and mistakes should be fully recorded.

In central color-scotoma the impairment is so marked that mistakes will always be made until the eye is brought very close to the lantern. But the examiner must watch that the eye is not turned slightly to one side, so that the image of the light can fall outside the scotoma, where its color would be recognized.

What cases should be referred to an expert examiner?

All found to have imperfect color-perception who are dissatisfied with the general tests. The expert may repeat the above tests, and vary them so as to demonstrate to the officers of the road, to fellow-workmen, or even to the applicant himself, his inability to recognize colored signals. Thus the signal colors of Thomson's lamp may be altered by combination with the smoked glasses as colored signals would be altered by fog, rain, or snow. Or the cobalt, pink, and green glasses may be used to render more striking the ordinary mistakes of the color-blind. Dirty signal flags may also be used, or the ordinary signal lantern, if it can be placed at the full distance at which safety requires that the engineer should be able to recognize it.

How is impairment of vision after admission to the service to be guarded against?

In nearly all cases in which color-blindness exists with good acuteness of vision it is congenital. Acquired color-blindness is usually attended with impairment of vision for form. But such impairment may be slight, although a central scotoma for colors is absolute. Repetition of the test for acuteness of vision after each accident or severe sickness, and at certain intervals, will reveal these acquired defects.

But they might exist almost the whole time elapsing between the examinations before the disqualification for service was recognized by the authorities. The man himself will, however, become conscious of such a defect as soon as it occurs.

Safety will be best attained by exclusion from the service of those whose use of tobacco and alcohol render them especially liable to color-scotoma; and by making such provision for men who are disabled by acquired color-blindness as will encourage them to report promptly for examination on perceiving evidence of any defect of sight.

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